POWER

McGraw-Hill Co., Inc., New York

Are You Reading This Stoker Story?

During the coming year we shall endeavor, in our POWER advertisements, to discuss the stoker question from as many angles as possible.

Some of our advertisements will deal with the relation of stokers in general to power plant requirements—especially **industrial plants.** Most of them, of course, will deal with the application of the TAYLOR **Stoker** and the TAYLOR **Power Dump** to your needs. All of them will be constructive.

The subjects chosen will be of interest and we will try to have them interestingly written up.*

Engineers are invited to write us regarding questions raised in these advertisements. We will be pleased to hear from YOU.

*Please note inside pages 6 and 16.

American Engineering Co.
Philadelphia

The Taylor Stoker

Men who *Guess* their boiler tubes are clean will be *"Out of Luck"* when it comes to apportioning coal on the efficiency basis

There is an agitation on foot to eliminate the manufacturer whose boiler room is run on this basis:—"I **guess** I have no scale," or "I don't think I have any." "I am **quite sure** the draft is correct and I **don't think** any of the heat is going up the stack unused."

Democracy has no time or material for the **"guesser"**—it wants and demands the man who KNOWS—the man who has taken the trouble to find out definitely and accurately—the engineer who, having personally used every means to free his boiler tubes from scale, can boldly say, "I **know** I have no scale because I have investigated." "I **know** my CO_2 average is correct, because I have tested it."

The Dean Boiler Tube Cleaner and Hays Gas Analysis Apparatus take your furnace operations out of the realm of guesses, maybes and perhapses—and put them upon the basis of scientific demonstration. The Dean takes off the scale—ALL OF IT—preventing overheating and burning out of the tubes, shows up dangerous leaks, spots the thin places, and increases the steaming capacity.

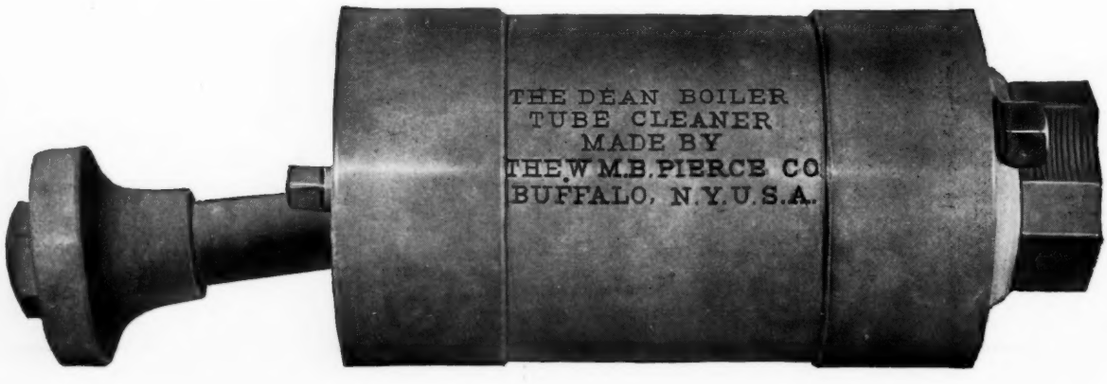
With the Hays Apparatus you can tell at any moment exactly what the furnaces are doing, exactly what percentage of fuel you are using profitably, exactly how much is going to waste, exactly what the draft should be, and whether there is any structural defect in the boiler settings.

Try a Dean in your boiler tubes—**don't guess.** Prove that you either have or have no scale—**stop guessing.** Let an actual demonstration show you for sure—guessing is too expensive. Tell us to send you a Dean for free trial—at our expense. Buy if you want it—return it if you don't.

Or if you want more data, write for the "Logic of the Dean," and "How to Cut Coal Costs."

The Wm. B. Pierce Company

Franklin Building, Buffalo, N. Y.



POWER

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Fooling One's Self

Contributed by R. B. DALE

THE EASIEST PERSON in the world to fool is one's self. There is a very good, logical reason for this. As a matter of fact, most of us believe just what we want to believe. The engineer, of all men, because of his training and experience, should be more proof against this mistake than others. The engineer learns to base his decision on facts. Business life today presents some very unpleasant awakenings for the man who bases his convictions on impressions rather than on facts and principles. The engineer marshals the facts together, estimates their value and reasons logically therefrom. Such a man is not likely to be in the wrong very often.

The Irishman who took off his coat, rolled up his sleeves and stated that he would like to see the man who could convince him that he was wrong, evidently was not very anxious to be convinced. Fooling one's self is a popular game. The man who really wants to know whether or not he is fooling himself uses every possible means to test his ideas. He who could lick the big Irishman would not necessarily prove that the Irishman was in the wrong, but the premise would be in that direction. Because the expert scorns your favorite idea, it does not necessarily follow that you are entirely wrong, but it does mean that you must put it to the most rigid test.

THE OTHER DAY a man put a little white powder in a pail of water and then threw the water on some coal that he put in the furnace. He wanted the dope to make good. He wanted it so badly that he did everything in his power to create favorable conditions. He had a better fire. He made less smoke. He made more steam with less coal. He thought it was the dope that caused the improvement. As long as the white powder lasted that fireman had wonderful results, but as soon as it was gone he unconsciously went back to his old, slipshod methods of firing. That man was fooling himself. He would have done even better without the dope had he taken the trouble to improve his methods.

Another man had an idea that he could get remarkable efficiency out of a boiler plant by preheating the feed water in a separately fired heater. He wanted his scheme to succeed, an therefore he used every means in his power to make it succeed. He created favorable furnace conditions. He watched the apparatus with great care and directed its entire operation. He got increased efficiency, but he did not stop to consider where it came from. Experts told him that if he had used the same careful methods, he would have gotten similar results, heater or no heater. He was fooling himself.

DO YOU BELIEVE the methods in your plant cannot be improved upon? Do you think that you cannot get more power with less coal than your records now show? That's where you fool yourself. There are no methods so good that they cannot be made better. It has been asserted that about one-quarter of the coal burned is wasted. How much do you contribute to that waste?

Are you doing the best that can possibly be done with the facilities and equipment at hand? Of course you think you are and that is fine, but how about improving the equipment? The "old man" won't be convinced. That's where you fool yourself. Business men were never so eager to install coal-saving and money-saving equipment as they are today. Have you tried to put the matter before him in a clear-cut, logical way, and have you proved to him what savings might be made with the new facilities?

Are you fooling yourself?

Turn the searchlight of investigation on your own methods. It will pay.

Condensers with Seventy-Foot Water Level Variation

By F. R. BROSIUS

These condenser wells are five in number. The intake well is 86 ft. deep and 60 ft. diameter. Two condenser wells will contain all the condensing equipment; each is 84 ft. deep and 68 ft. diameter. The two discharge wells are 17 ft. diameter. These wells are necessarily deep owing to the fluctuating water in the Ohio River, which is about 70 ft. between extreme low- and extreme high-water levels.

THE most interesting and unusual feature of the West End Power Station of the Union Gas and Electric Co., of Cincinnati, Ohio, which is now nearing completion under the supervision of Sargent & Lundy, is the type of substructure construction adopted to assure a satisfactory supply of condensing water under unfavorable conditions and to support the great weight of the building and equipment on unstable ground.

The site chosen for the station was the location of the company's old artificial gas plant, which was abandoned when natural gas was brought to Cincinnati and which had to be torn down before the new station could be built. This location is on the north bank of the Ohio River, which at this point fluctuates in level about 70 ft., due to spring floods in the valley above Cincinnati. At the extreme high-water mark, the gas-works tract was covered with six to eight feet of water. The ground consists of a fill of cinders, slag, etc., about fifty feet deep, resting on native sand and gravel at

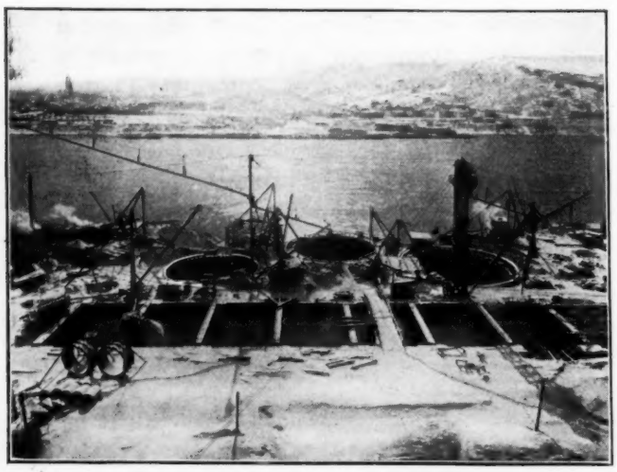


FIG. 1. CONDENSER WELLS BELOW TURBINE ROOM

an elevation of approximately 440 ft.—making the surface approximately 490 ft. above sea level.

Obviously, under such conditions the conventional arrangement of the turbine-room equipment would not be feasible, because of the excessive lift of condensing water that would be required under normal operating conditions—that is, at all times except during flood stage of the river—if the equipment were placed high enough to be safe from water at all times. To overcome this obstacle, the construction described in the following paragraphs was used.

The building is constructed with a river wall tangent to a chord of the harbor line drawn to the property

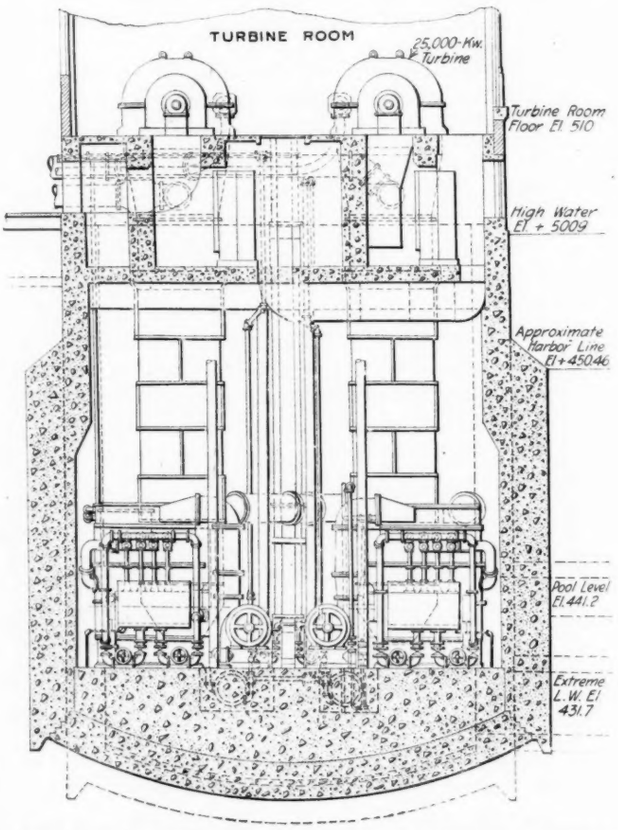

TURBINE ROOM
25,000-Kw. Turbine
Turbine Room Floor El 510
High Water El + 500.9
Approximate Harbor Line El + 450.46
Pool Level El 441.2
Extreme L.W. El 431.7

FIG. 2. CROSS-SECTION OF THE WEST CONDENSER WELL

line, the harbor line at this point being an arc of a circle of 4077.56 ft. radius. The turbine room is on the river side of the building, with its basement floor at an elevation of 502 ft. 15 in. above sea level and the main turbine-room floor at an elevation of 516 ft. The boiler room is north of the turbine room, with the basement floor 504 ft. and the main floor 522 ft. above sea level.

To provide for water, five wells were sunk below the turbine room, arranged as shown in Fig. 1. The center one is the intake well; on either side of it is a condenser well, and between each condenser well and the intake well there is a discharge well, Fig. 3. Tunnels run from the river into the intake well and from the discharge wells into the river bed.

The intake well is 86 ft. deep from the basement floor to the well floor and is 60 ft. inside diameter. This depth brings the bottom of the well to a level approximately 16 ft. lower than the extreme low-water mark, assuring a plentiful supply of water under all

river conditions. It has solid reinforced-concrete walls, 6 ft. thick, from the bottom of the well to the basement floor. This well contains a heavy bar-iron grill to remove the coarser débris floating in the river, and behind the grill traveling screens remove any rubbish not caught by the grill. A set of stationary screens is also provided to supplement the traveling screens when necessary. The intake tunnel leads into the bottom of this well. It is 163 ft. long from the river bed to the wall of the well and is 25 ft. high by 10 ft. wide inside, with reinforced-concrete walls 2 ft. 6 in. thick. The mouth of this tunnel opens into the river

west condenser well only is used for the initial installation of two 25,000-kw. turbo-generators, Fig. 2, the east well being reserved for a future increase in the capacity of the plant. This well contains all the condensing equipment for the two turbines, which exhaust through pipes 13 ft. in diameter and 62 ft. long into vertical condensers, each with 52,000 sq.ft. of cooling surface. These condensers and all auxiliaries and sump pumps are placed on the floor of the well, which is 68 ft. below extreme high water.

The discharge wells are 17 ft. inside diameter, with walls 3 ft. thick. As with the condenser wells, only the

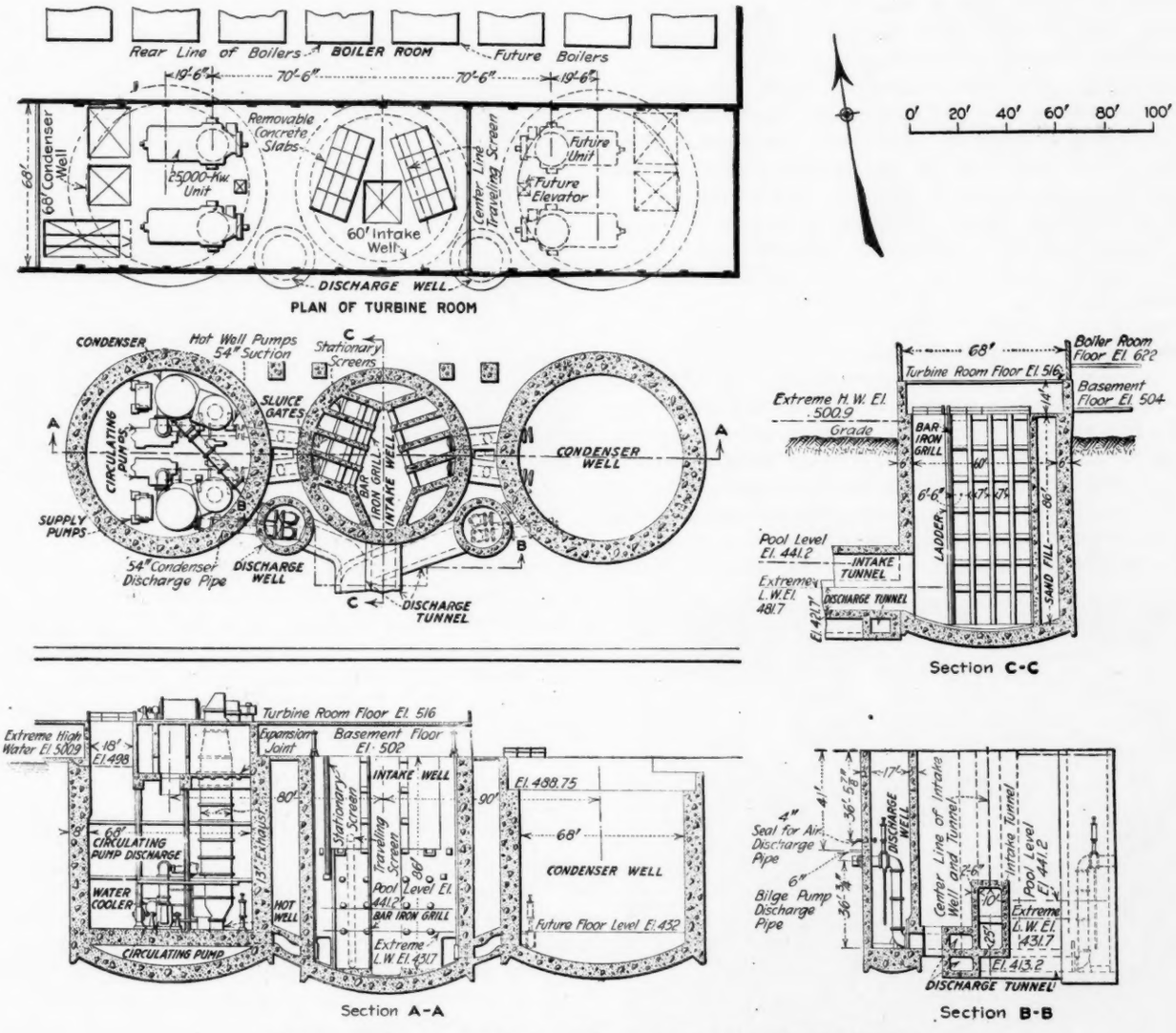


FIG. 3. PLAN AND SECTION OF CONDENSER AND INTAKE WELLS

on the slope of the harbor line, avoiding any projection into the river, and is supported on piling to prevent any damage due to undercutting by the river. The river bed for a radius of 25 ft. from the tunnel mouth is riprapped to prevent erosion.

The condenser wells are each 68 ft. inside diameter and 84 ft. deep from the basement floor, and are watertight to a point above the flood stage of the river. The floors of these wells are of solid concrete 16 ft. thick at the walls and 30 ft. thick in the center, and the walls are of reinforced concrete 8 ft. thick. The

west discharge well is used for the first installation. Two discharge pipes from the west condenser well enter the discharge well at the level of the top of the condensers and drop to the bottom of the well, where they are sealed into the end of the west branch of the discharge tunnel. Two tunnels, 6 x 10 ft. inside, one from each discharge well, meet at a point south of the intake well and below and west of the intake tunnel, and form a single discharge tunnel 10 x 10 ft. inside, with walls 2 ft. 6 in. thick, which extends 214 ft. in a downstream direction from the intersection, into the

river. The construction of the mouth of this tunnel is similar to that of the intake tunnel.

In the operation of the plant condensing water will be drawn through the intake tunnel into the intake well, where all foreign matter will be removed from the water by a grill and screens. It will then pass through 54-in. suction pipes extending from the intake well through the floor of the condenser well to the circulating pumps, then through the condensers and in 54-in. discharge pipes to the discharge well, and back into the river through the discharge tunnel. The entire water system from the point where the water enters the suction pipes in the intake well to where it leaves the discharge tunnel in the river is a closed siphon, thus making any lift of water by the circulating pumps unnecessary and making their only duty that of overcoming friction in the piping and condenser tubes.

The method used for sinking the three larger wells is of interest in itself. An excavation about ten feet deep and with a diameter greater than that of the well was made on the site of the well, and a circular steel shoe, or cutting edge, made of 12-in channels laid flat with plates riveted to the outer flange, with its outside diameter the same as that of the well to be sunk, was set up on the bottom of the excavation. Concrete forms were then set up on the shoe, arranged for concrete the width of the shoe at the bottom and then by 12-in. steps reaching the full thickness of the wall. Concrete was then poured in to make a ring 12 ft. high. When this had set, the forms were removed and the excavation continued inside the ring, allowing the ring to sink of its own weight. By continuing this process of alternately building the ring higher and then excavating and allowing it to settle, the well was sunk to the desired depth. When this had been reached, water

FIG. 4. INTERIOR VIEW OF ONE OF THE WELLS

was let in the well and the inverted dome-shaped bottom concreted under water by the use of a submarine bucket. Then, when this had set thoroughly, the water was pumped out and the remainder of the concrete bottom put in. The discharge wells were started in the same way as the larger wells, but were finished as closed caissons under air pressure. Figs. 4 and 5 are views of the interior and exterior of the wells respectively.

Part of the weight of the turbine room rests on these wells. The rest of the weight of the building and equipment is supported by nine rows of concrete piers, which were sunk to firm native bed gravel, at depths varying from sixty to eighty feet below the surface of the filled ground.

In this article only a description of the system of wells has been attempted, as a detailed story of the

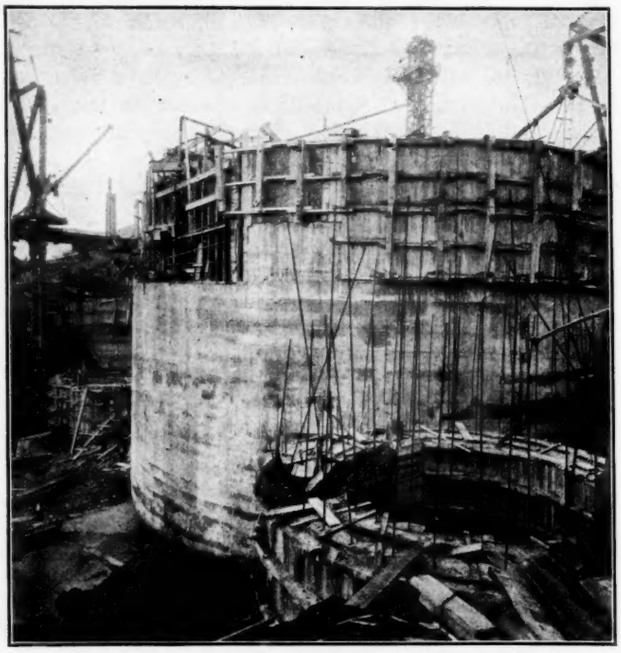


FIG. 5. EXTERIOR OF WELLS, SHOWING FORMS IN POSITION

entire plant will be published when it reaches completion. The writer acknowledges his indebtedness to the engineers of Sargent & Lundy, who planned the station, and of the Foundation Co., who built the plant, for their coöperation and assistance in preparing this article, and to C. R. McKay, consulting engineer for the Union Gas and Electric Co., for the photographs reproduced herewith.

Abstracts from an Engineer's Letters

Dear Friend—Replying to your inquiry as to whether "the design of a boiler joint can be brought out so a common, everyday engineer and fireman can make it out without the use of so many letters and combinations of letters that the whole matter is befogged," I will say of course it can, but the use of letters is more convenient when you get accustomed to them. In justification of the use of letters and their combination into groups, it may be said that almost every engineer or fireman does exactly the same thing in his daily conversation, where no effort is expended in writing it out and no valuable space is used up on a printed page. It is simply a short mode of expression. He hails his mate as "Bill" instead of Mr. William Muldowney, for example. The only thing necessary is a mutual understanding of just who is meant when "Bill" is called; for if there are others of the same name, there must be some other distinguishing name or letter and in many places the true initials are used, as "Hello, B. M."

One of the first expressions met with in the discussion of the boiler and boiler joint is the "tensile strength" of the plates or the material entering into boiler construction subjected to tension. If, however, the expression is to be frequently used, the initial T (sometimes TS) is used instead of the full name, as in the case of "Bill." Of course it must be known what the term tensile strength (T) means or stands for, but that is easy. If a bar of any material of convenient length is stressed (pulled) in the direction of its length with sufficient force, it will of course pull apart, and with means of measuring the extent of the force applied (pounds pull) the total force is known. An ordinary spring balance may be used to test the force necessary to break a small cotton cord and be satisfactory for that particular cord, but for comparison with cord of another material the size (thickness) of each must be known, so in testing the "T" of iron and steel the standard unit of one square inch has been adopted.

Therefore T is understood to represent the stress in pounds required to pull apart a bar of one inch square section, or its equivalent, which may be a bar one-half inch thick and two inches wide or any such combination of dimensions. Furthermore, the test piece does not necessarily have to be equal to one square inch so long as its actual measurement is known, for if it equals one-half a square inch (not, however, one-half inch square, or measuring one-half inch on each face, which would be only one-fourth of a square inch) and withstands one-half the strain that a bar one inch square does, their T is the same. If the plates from which a boiler is made are not good (low T), evidently its ability to resist the steam pressure which tends to pull the fibers apart will be correspondingly less.

Taking, for an experiment in the design of a riveted joint, a couple of strips of plate 10 in. wide and $\frac{1}{2}$ in. thick and stamped T 60,000, the solid plate would be expected to pull apart at $60{,}000 \times 10 \times \frac{1}{2} = 300{,}000$ lb., since there are 5 sq.in. area times (T) 60,000. But since it is necessary to drill holes in the ends to joint the pieces together, it is obvious that the total strength of the sample will be correspondingly less. The question then arises, How many holes will it be necessary to drill and what size? If five 1-in. holes are drilled in a line, then one-half of the width of the sample is cut away and the "net section of the plate" is only 50 per cent. of the original, and therefore the joint at best can only be one-half, or 50 per cent., as strong as the plate. Besides that, How about the rivets? Suppose rivets made of lead are used, the joint will not stand much of a pull because the lead will shear off easily. A quality, then, that the rivet material should possess is resistance to shearing action. This is designated as S (just another fellow's initial), so S = shearing strength and its value is anywhere from 35,000 to about 42,000 lb. per sq.in. cross-sectional area as before, only the strain is across the bar instead of endwise. Suppose, then, that the rivets used are square and each is one inch square and $S = 37{,}500$, how many will be required to equal the strength of the sample already drilled with five holes? Answer: $300{,}000 \div 37{,}500 = 8$ rivets. If the 8 are put in a row there will be a loss of $\frac{8}{10}$ of the original width of the sample, so they must be placed in two or more rows or other means used to improve conditions, and this leads a step farther.

A joint made by lapping one edge of the plate over the other serves well enough for some purposes, but the strain tends to kink the plates at the weakest point, which is at the rivet holes, therefore it is best to bring the plates edge to edge and to use a narrow "strap" to join them, and it is also advantageous to use such a strap on both sides of the plates so that the rivets will extend through both straps and the plate between. This is termed a "double butt-strap joint," and incorporating the statement of the type and number of rows of rivets gives a full description of the joint, such as "triple-riveted double-strap joint," etc.

When double-butt straps are used, the rivet will tend to shear at two points of its length instead of one, therefore it will withstand a greater strain, and this has been variously stated as $1\frac{3}{4}$ to 2 times the single shear. The A. S. M. E. Boiler Code Committee has adopted the value as twice S (stated as $2S$ or SS by different writers) for rivets in single shear, and this is being generally adopted.

To get back to the experimental joint, then, four rivets in double shear will do as well as the eight in single shear or will equal the T of the sample, but this still leaves the joint strength only 60 per cent. To increase the efficiency, then, the holes must be smaller and spaced farther apart; that is, less of the plate cut away in a line across the plate in drilling rivet holes. This is accomplished by increasing the pitch in any row (pitch is abbreviated to P), spacing the rivets farther apart, always measured from center to center, and putting in as many rows as may be needed to get the desired shearing strength. There are limitations to pitch on account of calking the joint steam-tight.

Another term met with is "crushing strength" (called C for short) which means that the part of the plate directly in front of the rivet may crush, the same as a bar of flat iron, if set up edgewise and subjected to extreme pressure, would crush. This must not be confused with the tearing out of the rivets through the edge of the plate. The crushing strength (C) of boiler plate, as indicated by numerous tests, is about 95,000 per sq.in. section, so that value is generally accepted as the value to use in all calculations; but since C is such a high value, it does not demand serious attention, for the joint is more likely to fail otherwise before the limit of C is reached. The thickness of the plate is shortened to t and the thickness of the butt straps to t_1 or these may be varied by different writers, but a list of abbreviations is, or should always be, given so there need be no confusion in a given case.

As suggested before, the net section of the sheet between the rivets is the part that is left to resist the strain (this is called the ligament), and the same applies to the slant distance between adjacent rows; so the rows must not be too close together, for the plate may fail in a zigzag line from a rivet in one row to an adjacent one in the next row and back, even though the pitch of a given row be sufficient. This is not likely to happen if consideration is given to the manufacturing process, for space must be allowed for the "dolly" used in riveting.

I think you and your friends will have a lot of fun designing joints (on paper) and testing them out by critical analysis and incidentally become familiar with the "nicknames" used.

A Talk to Firemen on Saving Coal*

By CHARLES H. BROMLEY†

A simple, straight-from-the-shoulder talk to firemen, giving in one lecture the most important things to do to get the most out of coal with the hope that firemen and their employers will become interested enough to further study fuel economy as the problem confronts them.

FIRING is an art that cannot be learned from books. Experience alone is teacher. But one becomes a much better fireman in a given time by studying and by hearing what those who have studied the subject have to say. That is why your good friends in Baltimore have arranged this meeting for you.

Of course it is impossible in one lecture to tell you all I want to tell you; but I will touch the most important points, hoping you and your employers will become interested enough to take up the subject and each study his individual needs.

Employers Need Education

So much is at present said about how firemen waste coal and how necessary it is to educate them, that I am impelled to say that the employers of firemen need more education on the use of fuel than do the firemen themselves. The most skilled and technically competent fireman cannot burn coal economically unless the boiler and furnace are, first, suitably designed for the coal used and, second, properly maintained in repair and cleanliness. In the average plant the fireman has nothing to do with design and little to do with repair and upkeep. The engineer or superintendent is properly responsible for these. The fireman is shown the boilers, given the most ragged-edged scoop (the older fellows on the job have grabbed the best ones) and put to work. Firing is hard and dirty work, and the class of men in boiler rooms becomes less congenial every year. These are the conditions.

The employer should learn that he must furnish the most suitably designed furnace and apparatus if he expects good results from his boiler room day in and day out.

The days of hand-firing are numbered. The great variety of mechanical stokers put on the market in the last few years adapts the stoker to almost any coal and any size or number of boilers. There is every physical and labor reason why the commercially unavoidable waste of coal by hand-firing should cease. Firemen, therefore, should visit stoker-fired plants and study the construction and operation of the many types of stokers. Ask your employers to send for the various stoker catalogs and give them to you. But do not use them to set the coffee pot on.

The more the fireman knows about the fuel he burns, and how and why it burns, the better he can burn it. The fireman's job is to put into the water in the boiler all he can of the heat in the coal. To successfully burn most soft coal, the combustion chamber must be of large volume and, for some types of boilers, have arches and wing walls to thoroughly mix the gases rising from the coal. The hand-fired horizontal return-tubular boiler and most hand-fired water-tube boilers should be set so that the heating surface nearest the fire is 60 to 72 in. above or away from the fire. The distance for stoker-fired boilers should never be less than 60 in. If the settings leak, find the cracks by passing a lighted candle over and near the brickwork or by passing the hand over the setting. Fill the cracks with a mixture of old asbestos from discarded pipe covering and fireclay or cement, or with some one of the several preparations on the market.

It is to be assumed that the baffling is tight so that the gases do not go to the stack without passing over the heating surface.

The following refers to soft coal: Coal is composed of carbon, tarry substances in solid form and refuse. The more tarry substances the coal contains the more smoky it is. When heated, the tarry substances vaporize, like ice melts, then vaporizes, if thrown on the stove. The vapors from many coals begin to be driven off at temperatures as low as 400 deg. F. The usual furnace temperature of a hand-fired boiler is 1800 deg. or higher. This explains why soft coal smokes when thrown on a hot fire—the vapors are driven off so rapidly and are so dense and the furnace temperature so reduced by blanketing the fire that smoke or vapor instead of gas forms.

Hints on the Care of Fires

The following instructions apply particularly to soft coal, hand-fired, but are true in general for hard coal.

Starting the Fire: Cover the grate with about three inches of lumpy coal. On top of this throw wood enough to start the fire; ignite the wood with oily waste. The coal will catch fire from the top down and will not smoke disagreeably. For hard coal and coal having less than 20 per cent. volatile, like the New River, Pocahontas, Clearfield and others, the fire will start better by throwing the coal on top of the wood. Do not try to make a thick fire at the start; keep it thin and hot by putting on the forced draft, if provided, except in a Scotch boiler or a newly set boiler. The reason is that the brickwork is cold and good combustion cannot be had until the brickwork, especially the arches, if there are any, is very hot. With most boiler furnaces, letting air in at the fire-doors after firing will prevent the formation of black smoke. If steam jets to blow air in over the fire are provided, use them for a minute or so after coaling the fire.

Holding the Fire: Do not carry the fire more than 12 in. thick. Cover it by coaling the fuel bed first on the front half; when this has burned through, cover the back half. If this method is not desirable, coke the coal by piling it at the dead plate. When coked as much as the condition of the fire gives time for, push the coking coal onto the fire. Cover the fire only where it burns away; that is, in the "holes."

*From a lecture to the firemen of Baltimore, Md., at the Baltimore City Club, Jan. 9, under the auspices of the Baltimore Engineers' Club, the Baltimore Section of the American Society of Mechanical Engineers and the City Club.

†Associate editor, "Power."

Use the slice bar seldom and be careful not to turn over the fire so that ashes or clinkers get on top of the live coals. If they get there, they will melt, run through the fuel bed and harden at the grate, plugging the air spaces. A very thick fire may have the same effect, except that the grate bars may become overheated and warp enough to ruin them. Run the slice bar between the grate and the fuel bed and raise the clinker enough to break it and let air through to the coal above.

With ordinary coal, if the ash and clinker give frequent trouble by melting, the cause is likely too high furnace temperature. This may be reduced by cooling the furnace arch over the fire, removing it altogether, exposing the bottom row of tubes if covered with tile baffling by putting the tile on the row above, or by bricking off part of the grate if the highest load can be carried with less grate area. The ash-fusing temperatures of Pocahontas, New River, Clearfield and Georges Creek coal are between 2400 deg. F. for the first to 2900 to 3000 deg. F. for the last. Most of the Pittsburgh and Kentucky coals have ash that melts at as high and few at lower temperatures than these.

Cleaning the Fires

The following directions are applicable to a stationary grate. Have plenty of live coal before beginning to clean. Push the live coal on the front half of the grate onto the back half; pull out the ashes, cover the bare grate with a thin layer of green coal and pull all live coal at the back of the grate forward onto the front half. "Jump" the ash from the rear over the fire and out the door. Cover the grate as before.

Some prefer cleaning one side half and then the other. The method is the same except that the live coal is pushed or "winged" over to one side, the grate cleaned of ash, covered with green coal and the live coal pushed back. The same is done with the other side of the fuel bed.

With shaking grates the ash is shaken into the ashpit; but if large, heavy and hard clinkers form, they should be pulled out of the fire. Shake frequently enough to keep the fire about eight inches thick and push the slice bar over the grate and under the clinker, lifting it enough to crack it. If the coal crusts over on top, break the crust with the rake frequently.

A Few Hints on the Stokers

With most stokers cleaning is done automatically; but if large clinkers form, they must be broken so the air can get through to burn the coal fed to the fire. The coal now being delivered in most localities contains half again to three times as much ash as that supplied before the war, and more serious clinker trouble results. No rigid directions can be given for getting clinker off the side walls without too quickly destroying the wall. Experience with the particular coal and brick in the wall must govern the operator. Be careful to break the clinker so as to burn the carbon out of it before the clinker gets on the dump plate, otherwise it will continue to burn there and in some stokers will burn out the plate. Break the clinker that piles up near the dump-plate so the air can get through it to burn out the carbon.

If the stoker has a clinker grinder and air may be admitted to the clinker on the grinder, be careful not to let in so much air as to overbalance what may be gained by burning the carbon out of the clinker. Experience gained by checking up with analyses of the gases and experience with the particular coal must govern the burning of carbon from the clinker. This is true whether the clinker grinder is run continuously or the clinker accumulated, ground and the carbon burned out periodically.

The more coal you attempt to burn the more carbon there will be in the ash, other conditions unchanged.

It will be found that for nearly every particular coal and type of setting there is a certain combustion rate above which it is uneconomical to go. For peak-load periods this rate is usually exceeded. The engineer must find this rate and instruct you accordingly.

Do not regulate the draft solely by the ashpit doors; use the back damper, which should be operated from the boiler front where the draft gage should be located.

Some General Hints

Keep the coal swept back away from the boiler front.

If you find you cannot help coal dropping off the shovel and going into the ashpit, tell the engineer so and let him put screens of ¼-in. mesh at the ashpit-door openings.

Pull the ash from the ashpit immediately after cleaning the fire, especially if the ashpit is shallow. This avoids warping the grate bars and prevents the formation of clinker. Keep water in the ashpit if it is very shallow.

Do not let the clinker form at the side walls so badly as to interfere with the feeding of the coal or enough to "arch" over the fire.

Never crawl under a fire to replace a grate bar that has jumped its bearing. It is too dangerous for you and too costly for the employer if you are badly injured.

Keep the business end of your scoop trimmed evenly. It won't spread coal rightly if it has a raveled edge.

If steam jets are used to create pressure draft under the grate, keep the jet openings free of the lime or other solids that come over with the steam and plug the tips.

If the fine anthracite is dry, wet it before firing, provided it cannot freeze before you want to shovel it. If it blows away at the dead-plate, clear the place and put lumps of coal or clinker over the slit from which the coal blows away.

Feeding water to the boiler is, perhaps, more important than feeding coal to the furnace. The feed water should be as hot as exhaust steam and live steam can make it, and there should be a thermometer in the feed line. Aim to feed water when the load is light and have a shade more than two gages full when the heavy load comes on, so that you can shut the feed valve almost entirely during the heavy load. When down to a little above the first gage-cock, open the feed valve just enough to keep the water going into the boiler as fast as it goes out in the form of steam. But make sure the injector or spare feed pump is ready for business in case the feed pump breaks down. If the water is such that it foams badly at heavy loads, keep it low and feed it continuously; that is, don't try to fill up the boiler and then shut off the feed when the heavy load comes on. Practice will tell how high a water level you may have before you get foaming trouble. Clean the fires during the lightest load periods only.

If the engineer neglects to keep in working order the dampers, damper regulator, the balanced draft apparatus, the feed valves, the feed-water regulator or anything important to the boilers' operation, pester him until he does act. If he is still negligent, every man jack in the boiler room report the conditions to the chief.

If stoker-fired, keep the stoker-coal hoppers full all the time and see that lumpy coal does not segregate at one side or both and fine coal in the middle of the hopper; otherwise you cannot keep a fire free of holes. The more uniform the size of the coal fed to the stokers the better fire you can maintain.

Never allow the wooden ladder to be taken from the boiler room, even by the chief himself.

It is foolish to try and cheat the CO_2 recorder or the gas-sampling tank. You can do it, of course, but you are the one who suffers. Play square with these watchmen, who, after all, are your best friends.

If the other fellow makes a better firing record than you do, don't get sore—learn from him. But if he cheats by shutting off the blowers on his boilers and makes yours do most of the work—well, use your own judgment.

I cannot say too strongly that opportunities for bright, studious boiler-room men are great now and will be greater as time goes on. There is always a good job, at good pay, for the man who knows the boiler room and how to get the most out of it.

M. I. T. a Military Camp

The remarkable registration of the Massachusetts Institute of Technology, which has today 88 per cent. of the students who were there in June at the close of the last school year, is due to two important factors: First, there was the plain statement by a student committee to its fellows that their patriotic duty was to "sit tight" and finish their studies, when they would be of much greater benefit to the country; and second, there were the summer military camps.

Two camps were established—one for sophomores (200 registered) at East Machias, Me., and one for juniors in Cambridge, Mass. The Institute has, on Gardner Pond, Me., a summer engineering camp ground of about 600 acres. Attendance there is obligatory upon sophomores in the civil-engineering courses. It was decided to utilize the facilities for a larger sophomore camp whose studies would be engineering as well as military.

Twelve weeks in uniform with military regime was the course, and to assure it to students to whom the uniform, transportation and camp costs would be a burden yet who were patriotic in wishing to undertake it, the expenses up to $25,000 were underwritten by Mrs. Edward Cunningham, widow of a former member of the Institute Corporation, through a memorial fund to her husband.

The work at East Machias included all kinds of engineering. Situated on the lower one of three large ponds, with considerable flowing streams at hand, hydraulics was an important topic. Railroad engineering was also taken up under natural conditions surrounding such work, and trenches were laid out and excavated. The summer was passed in this way, and the students were all the while engaged in the study of military science and evolutions and manual with considerable artillery practice. These students almost to a man returned to the M. I. T. for their junior year.

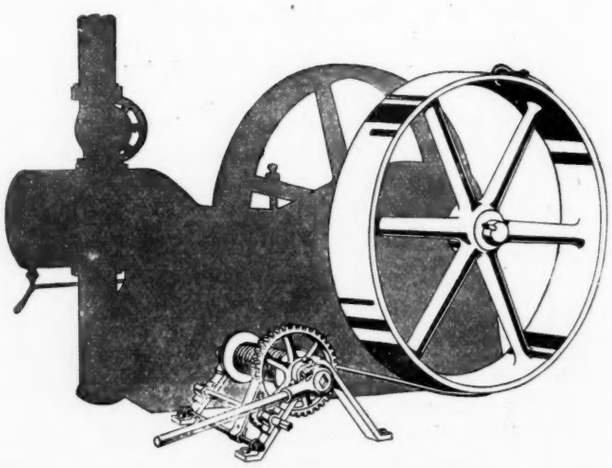
At the same time the junior camp was established at the Institute in Cambridge. This was a camp of nearly 200 students in khaki uniform, officered and taking calisthenics and military work. Students who wished to attend this camp but whose circumstances would ordinarily have caused them to seek positions during vacation had the benefits of the Cunningham memorial fund. There students with a long day, lasting till 5:30 p.m., not only had military training, but were anticipating the studies of the senior year so that they will actually receive their degrees a month hence and be able to go at once into that technical service which the country so much needs.

Institute men to the number of 1200 are already in khaki in positions of responsibility in all branches of military and naval service, while a larger body, more than 2000, are in the equally necessary supporting industries allied to war.

Engine-Turning Winch

Many devices have been used in power plants for turning engines off the dead-center. These are generally bars of one kind or another by which the engine is pried over, the bar gripping, or engaging in holes or notches in, the flywheel rim.

A different method of doing this work was recently seen in operation in a steam plant. The engine was a center-crank with flywheel governor. In the rim of the flywheel were holes for changing the governor for reverse running. On the floor in front of the



WINCH FOR TURNING ENGINE

flywheel was a winch, over the drum of which a wire rope was wound, the loose end having a hook. This hook is placed in one of the holes in the flywheel rim. On the extension of the winch shaft a ratchet is attached to which is fitted a handle.

With the hook in the hole of the flywheel the ratchet is operated, thus winding up the wire rope and turning the engine to the desired position. The winding spool is prevented from turning backward by a dog engaging with the gear teeth.

Gas-Engine Troubles and Remedies

By A. L. BRENNAN, JR.

Although during the past few years internal-combustion engines have reached a high degree of perfection, they are still subject to many of their former troubles. How these troubles may be quickly and intelligently diagnosed is told in the following.

THE troubles in gas engines can in the most part be avoided by careful attention, but at the same time they are liable to take place, even if an engine is in charge of an expert. It must not be understood from this that gas engines are not entirely dependable, for the service they are giving in all motive-power applications should be sufficient to convince even the most skeptical of their reliability.

Considering the fact that the functions of gas engines are partly performed by combustion, partly mechanical and partly electrical, it is not surprising that they cause trouble at times. When a gas engine refuses to start, it may be due to any one or more of three general causes—mechanical, fuel or electrical.

Mechanical troubles are:

1. Lack of compression.
   - a. Inlet valves stuck (automatic).
   - b. Inlet valves out of time (mechanical).
   - c. Broken, scored or worn piston rings.
   - d. Dry or worn cylinder.
   - e. Leaky gaskets or compression valves, etc.
   - f. Faulty exhaust valves.
2. Excessive friction.
   - a. Poor quality or insufficient lubrication.
   - b. Load not disengaged, or clutch sticking.

Fuel troubles are:

- a. Insufficient volume of gas allowed to cylinders.
- b. Improper gas mixture.
- c. Water in cylinders.
- d. Water in carburetor.
- e. Needle valve of carburetor clogged up.
- f. Pipe line clogged up.
- g. Gasoline supply exhausted or tank air-locked.
- h. Throttle not opened wide enough.

Electrical troubles are:

- a. Open circuit due to switch not in contact.
- b. Open circuit due to loose or broken wire.
- c. Short-circuit due to broken-down insulation on wires.
- d. Igniters hung up (mechanical make-and-break).
- e. Weak or depleted batteries.
- f. Poor contacts at timer.
- g. Vibrator contact points dirty or out of adjustment.
- h. Dirty or defective spark plugs.

Although there are many minor troubles that might be listed here, they would in general only tend to confuse the operator. The leading troubles, as outlined in the foregoing, should prove of benefit to the average engineer in helping him to quickly decide upon and locate an existing fault.

As a first step toward locating trouble in a gas engine the mechanical features of the motor should be tested by trying the compression. That is, crank the motor over with all relief valves and cocks closed; if considerable resistance is encountered on the compression stroke without any indication of binding, it is evident that the compression is good and that the valves and other actuating parts that control the compression are in good order. It must be remembered that each cylinder should undergo this test and if the compression is not satisfactory, the cause should be ascertained and remedied. No internal-combustion motor can develop its maximum power without good compression, although it may be able to operate in a fairly satisfactory way.

Also, if the compression is good, the features affecting the combustible are in all probability in good order as well. These have to do with the factors that control efficient carburization. Carburetors are an auxiliary feature of a gas engine for converting the liquid fuel into a gas, but at the same time carburization is largely dependent upon the condition of the motor. Therefore, any troubles that interfere with good compression, such as a badly pitted exhaust valve, for instance, also operate against efficient carburization, and, as already stated, this point is brought out by testing the compression. Therefore the first thing for an operator to do when confronted with difficulty to start is to try the compression; if this is good, the trouble is in the carburetor or the ignition.

When Motor Fails To Pick Up

Assume that the ignition is known to be in good order, and an attempt to start the motor is made but it fails to pick up, and each cylinder is primed and the motor again cranked over. If, now, the engine starts and runs in a regular manner, it shows that there was nothing much at fault to begin with and that the motor failed to start owing to lack of fuel in the cylinders when first cranked over. But on the other hand, suppose that after priming and cranking the engine it fired the priming charges and stopped, accompanied by sharp backfiring in the intake manifold or carburetor on four-cycle motors, or in the base or carburetor on two-cycle motors. Backfiring of this nature indicates a weak mixture, but does not necessarily show that the needle or air-valve adjustments are at fault, for the trouble may be due to the needle valve in the carburetor being clogged up or the flow of gasoline in the pipe line may be impaired by sediment or the tank may be airbound, etc. If, after priming and cranking the engine, no explosions took place, this would indicate that the motor is flooded. Therefore the next thing to do is to get rid of the extra gas, by closing the throttle, opening the relief cocks and cranking the engine over several times. It is a good plan to keep the switch on during this cranking, for then when the gas is thinned down sufficiently, firing will take place and the motor will start. Just as soon as the motor picks up its cycle, open the throttle a little and close the relief valves or cock and then advance the spark.

Remember that failure to start is not due to a retarded spark, and under no circumstances should the spark be advanced before the engine is operating under its own power. Failure on the part of the operator to fully retard the spark before cranking has resulted in many serious accidents. When a motor is started either with or without being primed and runs in a powerful manner for two or three cycles, but slows down or stops sluggishly, it is in nearly every case a positive indication of an over-rich mixture, consequently steps should be taken to reduce the amount of gasoline allowed or increase the volume of air.

On the other hand, suppose it appears that the ignition is at fault. The best way to see if the entire system is all right is to test the spark plugs, if the motor is equipped with high-tension coils. To test the plugs they should be removed from the cylinders, the high-tension wires reconnected and the threaded portion of the plugs rested upon the cylinder, care being taken to keep the top of plug and terminal from contact or near the cylinder. Then place the switch in position and crank the engine over to the several firing points—that is, to the firing point of each cylinder—and note if a spark takes place between the points of the plugs. If a good spark appears at each plug, evidently the ignition is good, but this should not be taken as final for the reason that a weak battery or poorly adjusted coil can produce a spark under natural conditions, but the same potential will prove inadequate to induce an electric arc in the high pressure inside the cylinder. Therefore this fact should be kept in mind, and unless an exposed plug shows a good, fat spark, steps should be taken to make up this discrepancy by adjusting the coil or using new batteries.

Another point to remember in connection with spark plugs is that the porcelain part is liable to crack and cause them to fail in their function, owing to the current leaking through the cracked porcelain and grounding.

If, when the motor was turned over to the firing point, no spark appeared at any one or more plugs, but the vibrators worked all right, this would show that the existing trouble is either in the secondary windings of the coil, in the high-tension wires or in the spark plugs. It is very rare that an operator is troubled by a defective coil, therefore the trouble is probably due to a loose high-tension wire or to a defective spark plug, and so the best thing to do is to change the spark plug of the faulty cylinder to one that is known to be in good working order.

On the other hand, if the motor was turned over to the firing point of each cylinder and each vibrator failed to buzz, it would indicate a weak or depleted battery, loose or broken wire in the primary circuit, poor contacts at timer or vibrator contact points dirty, pitted or out of adjustment.

Some Shaft-Governor Pointers

One evening as Willis was passing the plant of the Davis Machine Co., where a young fellow named Arnold was in charge of a couple of shaft-governed cross-compound engines, he noticed that Arnold was putting in some overtime, and as the latter usually made it a point to get away from the plant about as soon as the office boy, Willis stepped in to see if he could be of any help.

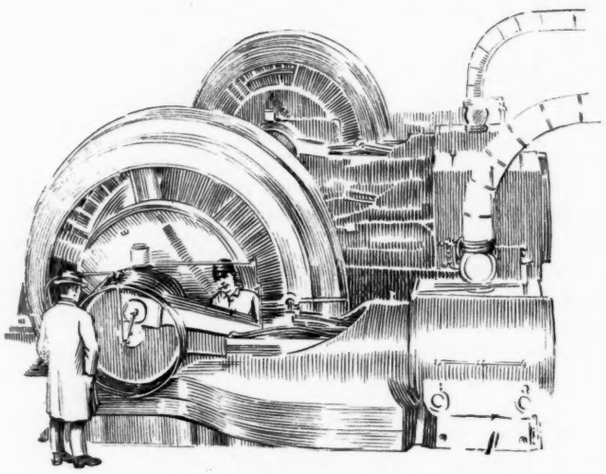
"What's the trouble?" he asked, as Arnold stuck his head up by the governor wheel. "I thought you would be at the movies by this time."

"Movies nothing," growled Arnold. "I have all the movies that I want right here with the blasted governor of this engine."

"What seems to be the trouble? Perhaps I can help a little."

"Racing, that's all. You'd think that the blamed engine was going to its first circus if the speed were anything to go by."

"Well, let's see if we can't get down to brass tacks before you take that governor down. What receiver



IT'S KIND OF FUNNY YOUR ENGINE SHOULD START TO RACE ALL OF A SUDDEN

pressure have you been getting since this trouble began?"

"Oh, around 45 to 50 lb. Of course that is high, but what can a fellow do? The plant has to run, racing or no racing."

"Sure, sure. But it's kind of funny that your engine should start to race all of a sudden, when it was running all right only a couple of weeks ago. Do anything to her since then?"

"Nothing to speak of," answered Arnold. "I did a little valve setting about a week and a half ago, but that hasn't had anything to do with the racing. How could it?"

"Now let us reason together, as someone has said. You carry about 115 lb. of steam at the throttle and get between 45 and 50 lb. receiver pressure. It looks to me as if there was something the matter with the valve setting. I'll bet your fireman will swear that you are eating up steam faster than you used to."

"He has kicked a little, but I told him it was his imagination. I don't see how it could be anything else."

"If I were you, Arnold, I would look at the valves just the same. Suppose we take off the bonnets and see what we shall see. I have an idea that you are blowing live steam right into the receiver from the high-pressure cylinder."

"I don't believe it, but just to show you that you are wrong we will look into things and see."

"There you are," exclaimed Willis when the valves were exposed to view. "Just what I thought. You

have given the steam valve about $\frac{3}{16}$-in. negative lead, and your piston will be at about $\frac{5}{8}$ of its stroke when the valve opens and keeps open until near the end of the stroke. At the same time the exhaust valve on that end of the cylinder is open and the steam doesn't do a thing but rush right out through the exhaust port to the receiver. Can't you see that you are working the low-pressure cylinder at a pretty high pressure? It's no wonder that the engine races. Let's set these valves as they should be and see what happens when you start up.

"Another thing for you to consider is that with this valve setting an excessive back pressure is set up in the high-pressure cylinder and of course that reduces the power developed by that cylinder. With the low-pressure cylinder doing the most of the work, it is out of the control of the governor and there is no reason why the engine wouldn't race. Now with these valves set properly, according to my notions, I'll bet a plugged ten-cent piece that your engine will govern all right."

When Arnold started up for a tryout, he found that the tendency to race had disappeared.

"Well, I'll be blown!" he exclaimed. "I wouldn't have believed I had set those valves so as to knock out that governor. I'll be more careful the next time."

"That is a good resolution to make, but every engineer should be so familiar with his engine that he knows just what he is doing when changes are made. And that applies to the governor. Many times poor regulation is due to a faulty governor—not so much in the design as to the wear of parts, which will frequently cause them to bind. A governor should be known to be in balance as to weights and friction."

"I don't get you," said Arnold as he seated himself on the edge of his desk. "How are you going to find out whether the weights and friction balance, whatever that is?"

"That's easy enough. All you have to do is to detach the springs from the weight arms and move the weights out to their full travel and back again with a free movement. If the governor binds, it is well in testing out to remove the eccentric rod so as to give the governor free action without having to drag the valve gear. Working the weight arm from one position to another will give a good idea as to whether there is binding in the parts or not. If there is a feeling of sticking, you won't have to guess very much as to where the trouble is."

"Suppose you do feel a sticking when working the weight arms, what are you going to do about it, and where would you look for the cause?"

"The first thing I would do would be to examine the pins and bearings to see if they were getting enough oil, or for caps binding on the end of the pins. If you feel a sticking of the movement, you can be pretty sure that the trouble is in some of the governor bearings or pins. Naturally, if after testing out the governor it is found to be all right, you will turn your attention to the valve gear. It may be that a pressure plate is binding, or the valve stem may bind in the stuffing-box. Flat pins can bring about a lot of trouble."

"I don't see why that should be," said Arnold as he started to remove his overalls and jumper preparatory to getting ready to go home.

"That's easy to explain. When an engine runs day after day with practically the same load, the bushings and pins will wear out of true, because the governor arms assume practically the same position during the run. Naturally, the pins and arm bearings wearing together have a free motion, but if the load changes to any great extent so that the weight arms take a new position, the bearing between the arms and the pins do not fit properly and excessive friction is set up, often so great that the governor sticks, the result being that the engine will race."

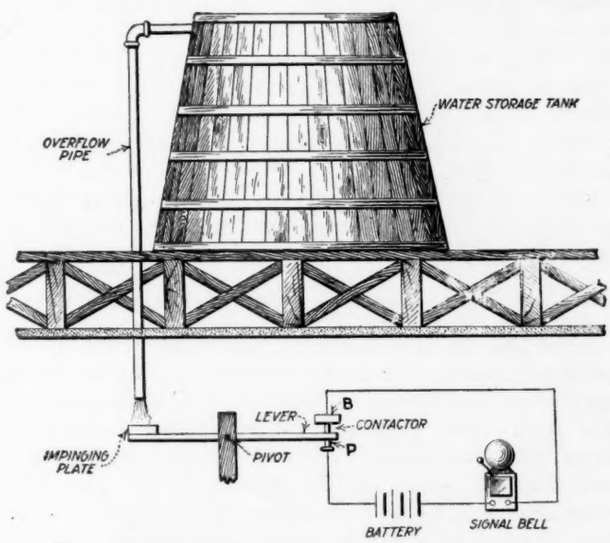
"I guess there is considerable in what you have said," answered Arnold. "One thing is sure and that is that poor valve setting will cause an engine to race, but for the 'love of Mike' don't go away from here and tell the bunch what a mess I made of setting those valves."

"I won't," replied Willis, as he buttoned up his overcoat. "I've been guilty of pulling off just such fool stunts myself"; and with this he left Arnold to wash up, while he hurried home to another belated supper.

Tank-Overflow Alarm

BY T. A. NASH

An effective tank-overflow alarm circuit is detailed in the figure. When the tank becomes so full that water flows through the discharge pipe, the water impinges



LAYOUT OF TANK AND ALARM CIRCUIT

on a block mounted on the end of a lever as shown. This forces the contact point *P* of the lever against the metal contact *B* and completes the signal circuit, causing the bell to ring.

Experience has shown that undercutting the mica is desirable on most commutators having peripheral speeds exceeding 1500 ft. per min. In the case of very low speeds, slight undercutting, possibly one sixty-fourth inch, may be desirable. Nonabrasive brushes should always be used with undercut mica, because where there is little wear on either brush or commutator, there will be practically no grinding off of either copper or carbon, hence no fine material to fill the grooves. In general, undercutting is entirely satisfactory for any machine operating at engine-type or higher speeds.

The Electrical Study Course—Forms of Field Magnets

Some of the earlier and the modern types of field-frame structures used for direct-current machines are described.

THE function of the field magnets in an electric generator or motor is to furnish the magnetic field, which in a generator is cut by the armature conductors to generate voltage, and in a motor reacts upon the current flowing in the armature conductors to produce rotation. In the development of the dynamo-electric machine the field magnets have taken on a multiplicity of forms. The field magnets of the earlier types of dynamos were permanent horseshoe magnets, similar to that shown in Fig. 1. Even today this type of field pole is used, in some cases, on small magnetos for ignition, signaling and other purposes. However, this form of magnet was never used on machines of any considerable size, chiefly because the magnets would have to be very large; the strength of the magnets decreases when in use, owing to the vibration of the machine and the effects of the magnetic field set up by the current in the armature winding; also because there is no way of controlling the strength of the field, which is the chief means usually employed for controlling the voltage of the generator or the speed of an adjustable-speed motor. These defects soon led to the adoption of electromagnets; that is, coils of wire placed on polepiece of soft iron and excited from some source of electric current.

Early Types of Field Magnets

Since the permanent-magnet field poles were of the horseshoe shape, it is to be expected that most all of the earlier electromagnets used for field poles were of this form. Fig. 2 shows one of the early types of Edison two-pole machine, and Fig. 3 is a somewhat later and improved type of the same machine. In this arrangement of poles, if they were mounted on an iron base it would short-circuit the magnetic field; that is, instead of the lines of force passing from the N pole across the air gap, and through the armature core into the S pole, they would take the easier path around through the iron base. To overcome this defect, a nonmagnetic plate of brass or zinc was placed between the polepieces and the baseplate, as indicated. To prevent the lines of force from leaking out along the armature shaft down through the bearing pedestals into the base of the machine and back into the polepieces, the pedestals were usually made of brass.

To get away from the nonmagnetic bearing pedestal and bedplate, the polepieces were turned upside down with the armature placed in the top, as in Fig. 4. With this arrangement the field magnetism passes from the N pole into the armature through the armature core into the S pole, and down around through the baseplate. Another form of field magnet is that in Fig. 5. This type was usually mounted on a wooden base, for the same reason that the nonmagnetic plate was used in Figs. 2 and 3.

In all the foregoing schemes the flux from the polepieces passes directly from one field pole into the armature, and then to the opposite pole and around through the field structure. Such an arrangement is called a salient-pole machine.

Consequent-Pole Type Machine

Another type of field pole used in the development of the electric machine is given in Fig. 6. In this construction if the top of one field coil is made north and the other south, the lines of force will flow from the N pole around to the S pole without ever passing through the armature at all. To overcome this difficulty the top ends of both coils are made the same polarity; therefore the bottom ends must also be the same polarity, as shown in the figure. In this arrangement the two N poles oppose each other, and the lines of force must take the next easiest path, which is down through the armature to the S pole. A machine having a field frame in which like poles oppose each other, so as to cause the flux to pass through the armature, is called a consequent-pole machine. One of the serious objections to this type is that the opposing poles cause a heavy magnetic leak around through the air from the N to the S pole; that is, instead of all of the flux passing from the N pole into the armature and then to the S pole, a large number of the lines fly out in all directions into the air and around to the S pole. This leak constitutes a direct loss. In all types of machines there is always a certain amount of magnetic leakage, but it is much more pronounced in the consequent-pole machine than in the salient-pole type.

Motors or generators with only two poles are called bipole machines; those having more than two poles, that is, four, six, eight, etc., are called multipolar machines. None of the types of field frames so far considered lend themselves readily to multipole construction, consequently very few of these types were developed into multipole designs.

Materials Used in Field Poles

The arrangements of poles in the field frame that have been exploited could be carried out almost indefinitely, but the one design that is now used almost exclusively is the arrangement shown in Fig. 7. This construction is of the salient-pole type; that is, there are no opposing poles. This design can be used as readily for bipole as for multipole construction.

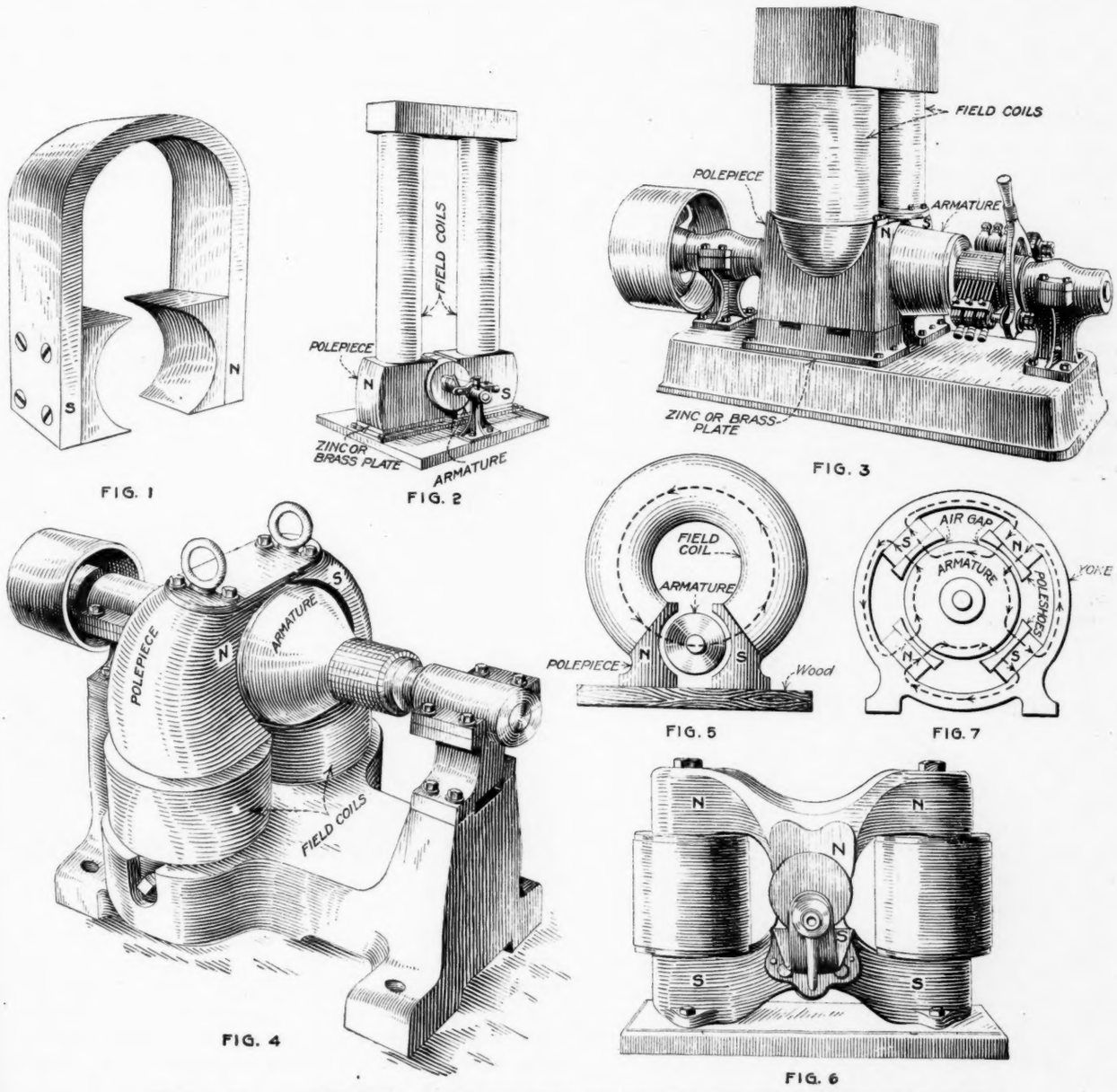
All of the earlier field frames and polepieces were constructed of cast iron or steel. In some of the modern types the whole field structure is laminated; that is, built up of thin sheets of iron or steel. Others again have a cast-iron yoke to which laminated polepieces are bolted. The yoke is the circular portion in Fig. 7. Other types have cast-iron polepieces with laminated poleshoes. The poleshoe is indicated in Fig. 7. This part is built up of thin sheets of iron or

steel and bolted to the cast-iron polepiece. This subject will be given a more detailed study in future lessons.

Fig. 8 shows the layout of the study problem given in the last lesson. The current required by the motors is equal to total horsepower $\times$ current per horsepower $= 37.5 \times 3.8 = 142.5$ amperes; the current consumption of the lamps equals the watts required per lamp $\times$ the number of lamps $\div$ volts $= 75 \times 64 \div 235 = 20.4$ amperes; and the total current is the sum of that required by the motors and lamps, or 142.5 + 20.4 = 162.9 amperes. The volts drop in the line is $E_d = E - E_a = 240 - 235 = 5$. Then the size of the conductor required is

$$Cir.mils. = \frac{21.4DI}{E_d} = \frac{21.4 \times 475 \times 162.9}{5} = 331{,}176$$

or the nearest larger size standard conductor is 350,000 cir.mils., which is the size that will have to be used. This size rubber-covered conductor can be used, since the National Board of Fire Underwriters allows it to be loaded up to 300 amperes. Total watts = volts $\times$ total current, or $W = E_a I = 235 \times 162.9 = 38{,}281.5$; total kilowatts $= \frac{W}{1000} = \frac{38{,}281.5}{1000} = 38.2815$. The total time during which the power was used is hours per day $\times$ number of days. In this problem $6.5 \times 26 = 169$ hours. Then kilowatt-hours = kilowatts $\times$ hours $= 28.2815 \times 169 = 6470$. The cost of the first 800 kw.-hr. at 7.5c. per kilowatt-hour is $800 \times 7.5 = \$60$. The next 1000 kw.-hr., at 6c. per kilowatt-hour, cost $1000 \times 6 = \$60$. The remaining kilowatt-hours $= 6470 - 1800 = 4670$, and the cost, at 4.5c. per kilowatt-hour, is $4670 \times 4.5 = \$210.15$, and the total cost is $60 + 60 + 210.15 = \$330.15$.



FIGS. 1 TO 7. DIFFERENT TYPES OF FIELD-POLES FOR DIRECT-CURRENT MACHINES

1. What will be the voltage drop per foot of copper wire 18,750 cir.mils. in cross-section, when transmitting a current of 35 amperes?

2. Three lamps having a resistance of 45, 90 and 180 ohms respectively, are connected in parallel at the end of a 75-ft. circuit, the conductors of which have a cross-

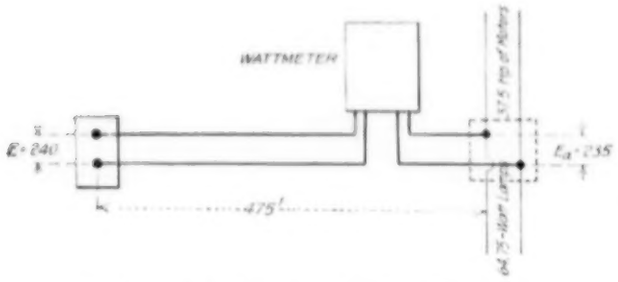
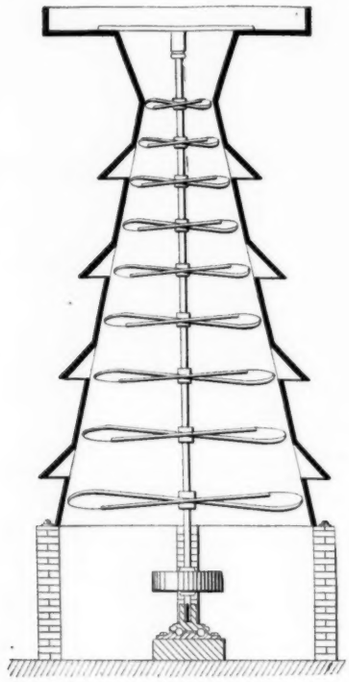


FIG. 8. FEEDER AND BRANCH CIRCUITS

section of 6530 cir.mils. If 135 volts are applied to the power-plant end of the circuit, what current will flow through the lamps? Also the current taken by each lamp?

Power Without Cost?

The Paterson (N. J.) *Morning Call* of a recent date contains the description a "near perpetual motion" discovered by a local inventor who, it is said, has been granted a patent on the device, which is expected to develop unlimited power by the upward rush of air through a conical stack or tower containing a vertical shaft on which are several propeller-shaped blades. "The apparatus may permit mills to discard coal."



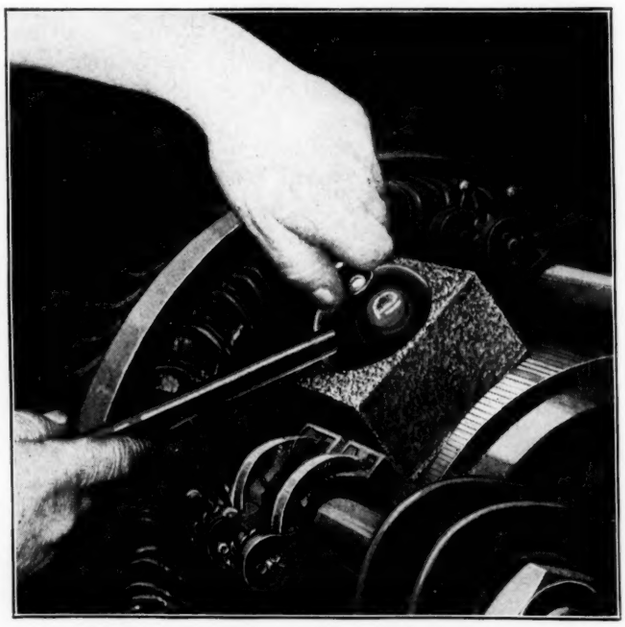
APPARATUS FOR DEVELOPING POWER

"Model develops 325 r.p.m." (doing no work except—overcoming its own friction presumably). The inventor "is too modest to permit the use of his name." "He does not wish his apparatus to be confused with so-called perpetual-motion machines." The reporter, however, suggests that "if the machine is as successful as he claims it will be, there is no reason why it should not be perpetual, as the air currents are continually mounting skyward." "It is not expected that one of these towers will furnish enough power for ordinary manufacturing purposes, but a whole battery of towers can be put in use at the same time," and "it will not be necessary to use any kind of manufactured drafts or currents."

Engineers will recognize the fallacy of the reasoning in the foregoing, in that there can be no upward flow of air except when the air inside a chimney is at a higher temperature, therefore lighter. A chimney is the simplest form of heat engine and at the same time probably the most inefficient. It costs something to "stir up a breeze" in any case, and even if it costs nothing to produce, it might easily cost more than it is worth to get any useful work out of it.

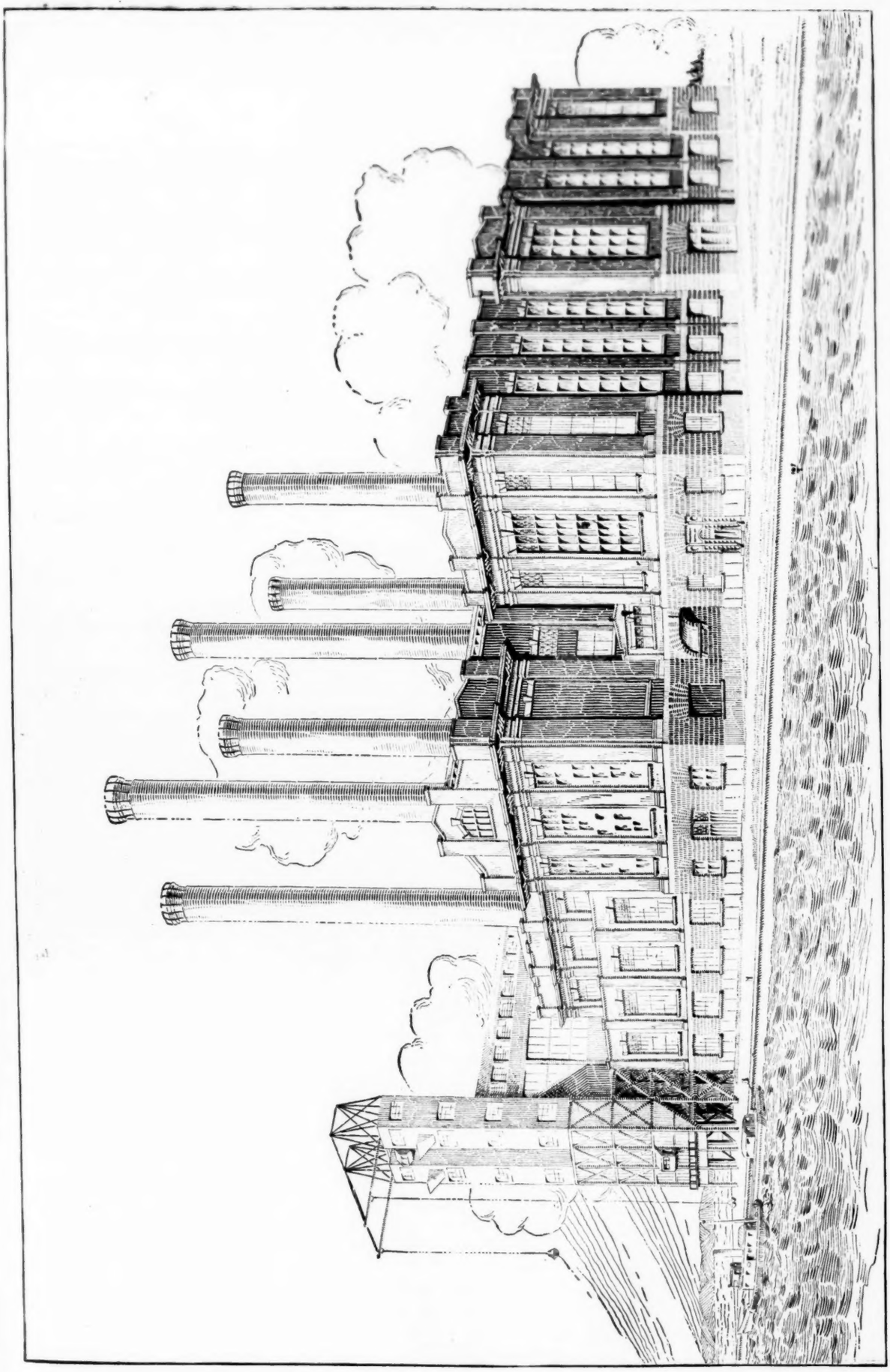
"Ideal" Commutator Resurfacer

A commutator resurfacer made of abrasive nonmetallic material has been perfected recently by the Ideal Commutator Dresser Co., 8 South Dearborn St., Chicago.



APPLICATION OF RESURFACER TO A COMMUTATOR

The resurfacers are made in various sizes to fit any condition of service. They are secured to permanent handles, giving the operator easy control of the device while on the commutator. The resurfacer is designed to do what would be accomplished by putting the commutator in a lathe and turning it down. There are two grades, known as coarse and fine. The former is recommended for bad commutators; the latter for a commutator in fair condition. Both cut down high mica, high bars and smooth out low spots, ridges and grooves. It is claimed that the abrasive material of the resurfacer does not collect copper dust nor wear smooth. Consequently there should be no short-circuiting, so that the device may be applied to a commutator or to collector rings while the machine is in operation. The illustration shows one of several designs of resurfacer with handle, made by the company.



Essex Station, Public Service Electric Co., Newark, N. J., as It Will Look When Completed

Ultimate capacity, 250,000 hp. Four stacks are now up

Work of the New Orleans Fuel Administration Committee

By LEO S. WEIL

This article describes the work being done by the New Orleans Committee of the United States Fuel Administration to conserve the supply of coal in that city under the direction of the writer, who is acting as Advisory Engineer to the committee. Considerable saving of coal has already been effected.

THE Fuel Administrator has appointed state administrators with advisory committees, whose duties are (1) to stimulate production, (2) to regulate prices, (3) to control the distribution, and (4) to conserve the supply of coal. While these duties are all important, those which deserve the greatest attention at the present time are stimulating the production and conserving the supply. If these two aims can be carried out successfully, there will be sufficient coal to satisfy the needs of all. The New Orleans Committee of the United States Fuel Administration has inaugurated an energetic campaign for fuel conservation, and an outline of the work being done will probably be of interest to other communities.

After a careful study of the situation, the committee decided that coal could be saved in three ways: (1) By the substitution of other fuel where available, (2) by shutting down unnecessary plants and lightening the loads on plants that must run and (3) by improving operating conditions. Steps were first taken to find a substitute for coal, and to this end a letter was sent to all woodworking plants in New Orleans and vicinity asking for a report on the amount of wood waste they had in excess of their own requirements, with the idea of using this excess instead of coal wherever it was commercially practical. To obtain this information "General Letter No. 4" was sent out.

Unnecessary Plants Shut Down

Investigation showed that the ice plants of the city operate in the winter months at about one-third of their normal capacity, and an arrangement was therefore made whereby a large number of these plants were shut down and the remainder run at nearly normal capacity supplying ice to those which were shut down. Coöperation to the same end has been received from other industries such as the laundries and the New Orleans Railway and Light Co., which have dispensed with all unnecessary loads. The greatest possibility of saving exists, however, in improving plant-operating conditions, and to this the committee is devoting much of its effort. The Government has appealed to mine workers to speed up the production of coal in order to take care of the increased demand, and it was thought that a similar plea could well be made to power-plant owners, their engineers and firemen not to waste coal, because any amount of coal saved would be of even more benefit than a corresponding increase in production, as it would release freight cars for other service. A meeting of the industrial-plant managers was therefore called, at which the necessity of fuel conservation and the individual duties of owners, engineers and firemen were impressed on those present. It was pointed out to the managers of the plants that one of the principal reasons that they did not receive the most efficient coöperation from their operating forces was because suggestions from the latter were not given proper consideration when these suggestions called for improvements entailing a small expenditure. They were advised to encourage suggestions from their engineers even if they did not always adopt them, because nothing stimulates the interest of a man in his job so much as the realization that his opinion is valued and that any improvement in results that he obtains will not pass unnoticed. The plant owners were given to understand that they would not be expected to make large investments to improve operating conditions, but that they would be expected to keep their present equipment in good condition and to utilize this equipment to the best advantage. "General Letter No. 6" was distributed, pointing out where most of the easily preventable wastes occur in steam plants, and it was requested that the various suggestions on this sheet be checked up to see that these wastes were cut to a minimum.

Committee of Owners Formed

The necessity of coöperation on the part of both owners and engineers was strongly urged, and it was decided to form a committee of owners and also an organization of engineers to assist in this work. In pursuance of this policy "Circular Letter No. 8" was sent to all industrial plants in the city, and it is gratifying to state that pledges of coöperation and support were received from all these plants. A committee of five industrial-plant owners has been appointed to confer with the advisory engineer and to help direct this work. "Questionnaire No. 9-A" has been mailed to the engineer of every plant in the city. The information called for on this questionnaire will indicate whether the results being obtained are as good as they should be and will help to show why they are not good if the efficiency is low. A committee of operating engineers will also be appointed to assist the advisory engineer in analyzing these reports, and suggestions will be made to each plant on the best method of improving its operating conditions. This same staff of engineers will also visit the various plants to study conditions and, after consulting with the engineer of that plant, will report to the owner on possible savings that can be effected. A similar questionnaire will be sent out each month, and the replies received will show what saving is being made. Posters that have been prepared by the United States Fuel Administration (General Letter No. 6) will be placed in every boiler room and an appeal made to the firemen to show their patriotism by following directions on these posters.

Both engineers and plant managers have shown every inclination to help the work along, and a considerable saving has already been effected, which will be increased as time goes on, and it is hoped that the results obtained will fully justify the effort made.

GENERAL LETTER NO. 4

To the Woodworking Plants of New Orleans.

Gentlemen: As an aid in the work of fuel conservation, the New Orleans Committee of the United States Fuel Administration request that you give them the following information:

1. What kind of power do you use to operate your plant?
2. Do you make any use of the wood waste obtained in manufacturing your product?
3. Does this waste exceed your own requirements, and what disposition do you make of the excess?
4. State the amount of this excess and advise whether you are willing to dispose of it to other steam plants in your vicinity.
5. Give the names of the plants in your neighborhood that might be able to use this wood waste as a substitute for other fuel.

If further information is needed by you in order to answer these questions, you will please communicate with the advisory engineer of the board, Leo S. Weil, 303 Whitney-Central Building.

Your prompt coöperation will be of great assistance to the committee, and is earnestly requested.

Yours very truly,
HAROLD W. NEWMAN, Chairman.

GENERAL LETTER NO. 6

To the Users of Industrial Coal in New Orleans.

Subject: How To Reduce Coal Waste.

1. Keep the heating surfaces of the boilers free from soot, scale and oil.
2. See that the baffling is in good condition and that the gases follow the proper path.
3. Be sure that the boiler settings are tight and free from air leaks.
4. Work your boilers up to their rated capacity. Do not have more boilers in operation than are necessary to carry the load.
5. Do not have too much grate surface for the size of the boiler.
6. Do not have openings in grates so large as to lose a large amount of combustible with the ash.
7. Fire light and often, spreading the coal over the thin spots in the fire.
8. Keep the fires level and free from holes.
9. Use the dampers to regulate the draft; not the ashpit doors.
10. Do not carry the fires so thin or have so much draft as to draw a lot of excess air through.
11. Do not carry the fires so thick or cut down the draft so much as to have incomplete combustion of the coal.
12. Admit some air over the fire to complete combustion.
13. Do not soak the coal with water before firing.
14. Be sure the blowoff valves do not leak.
15. Do not have the safety valve popping off continually.
16. Use your exhaust steam to heat the feed water; do not waste it.
17. Have the valves on your engines properly set.
18. Minimize radiation losses by covering steam pipes.
19. Do not allow the waste of steam through leaky traps, valves, etc.
20. Never use live steam where exhaust is available and can be used as well.
21. Do not have belts too tight or so loose that they slip; keep all shafting in line.

CIRCULAR LETTER NO. 8

To the Managers of the Industrial Plants of New Orleans.

In accordance with the suggestions presented at the meeting last Thursday night, it has been decided to form an organization of owners of industrial plants in this city to coöperate in the efforts for the conservation of fuel. All coal users in New Orleans will be expected to join this organization, and a committee will be appointed from the members to coöperate with the New Orleans committee of the United States Fuel Administration.

The members of the organization will pledge themselves to use every effort to save coal; to follow suggestions approved by the local committee to this end; to provide the necessary instruments for ascertaining their operating conditions; and to keep records of these conditions, which will be submitted periodically to the Fuel Administration.

The local committee is confident that the patriotism of all steam users here will prompt them to join in this work. You are requested to signify your intention of coöperating by filing your membership pledge with the committee not later than Dec. 21.

The engineers of the local industrial plants will also be organized for the same purpose, and you are requested to bring this matter to the attention of your engineer and ask him to pledge himself to the work, at the same time.

A meeting of the operating engineers will be called to discuss ways and means of conserving coal, as soon as the replies are received.

We urge upon you the necessity of this fuel conservation work, and feel that we may count upon your coöperation.

Yours very truly,
HAROLD W. NEWMAN, Chairman,
New Orleans Committee Federal Fuel Administration for Louisiana.

December ...., 1917.

Kindly enroll the undersigned in the conservation campaign of the United States Fuel Administration as above indicated.

.....
.....

Name of engineer employed:
.....

After signing the above, and furnishing the information requested, kindly return to the New Orleans Committee, Federal Fuel Administration, 402 Canal Bank Annex.

QUESTIONNAIRE OF THE POWER PLANT, NO. 9-A

(Date).....

Name of plant..... Manager..... Engineer.....
No. of boilers in plant..... make..... size..... grate surface.....
Plant runs....hr. per day....days per mo.....mos. per year
Daily output of plant in per cent. of maximum.....
No. of boilers operated.....method of firing.....
Kind of fuel used..... Amount per day..... Heating value.....B.t.u.
*Water evaporated per day.....per lb. of fuel.....
*Temperature of feed water.....
*Average stack temperature.....
*Average per cent. CO_2.....
*Draft in furnace.....in uptake.....(usual).
Usual thickness of fires.....
Do the firemen keep fires level and free from holes?.....
Are the boiler walls cracked or leaky?.....
Is the baffling in good condition?.....
Is the heating surface clean from soot and scale?.....
How often are the tubes blown?..... System of blowing.....
Do the blowoff valves on the boiler leak?.....
Are the valves on your engine properly set?.....
When indicated last.....
Is steam pipe covered?.....
Live steam used for.....
Exhaust steam used for.....
Can you suggest any way of reducing the fuel consumption of your plant, and how much do you estimate can be saved?.....

*If you lack instruments to measure these, say so.

THERE ARE OTHERS

Faulty Lubricating Methods

By Charles W. Oakley

The brasses of the eccentric rods on a large engine are of the marine type. An oil hole drilled through the end of the brass and an oil cup mounted on a pipe connection, as shown in Fig. 1, were to provide the means of lubrication. As a matter of fact, however, lubrication should be by way of the oil hole *A* in the top of the brasses, the cup being of little value because the oil fed from it flows to the bottom of the brasses and away from the pin, which has its principal bearing at the top. If the pin made an entire revolution instead of a slight rotating movement, the oil from the cup would do some good, but in any event the cup should have been mounted on top of the brasses with an oil hole leading down through the rod end and brasses to the pin.

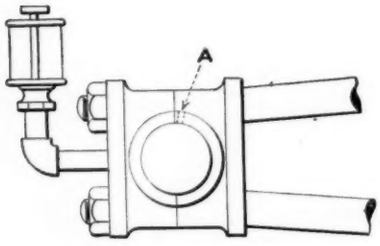


FIG. 1. OIL CUP SHOULD BE AT A

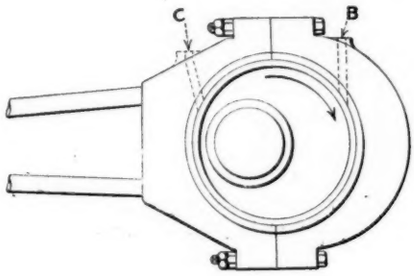


FIG. 2. STRAP SHOULD BE OILED AT C

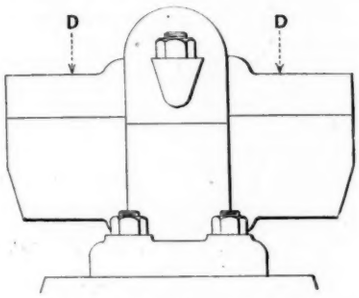


FIG. 3. SUGGESTED RINGS SHOULD BE AT D

Another case of poor design in applying lubrication is found on the eccentric strap of the same engine, where the oil is introduced through the strap at *B*, Fig. 2. As the direction of rotation is toward *B*, as shown by the arrow, most of the oil is carried down and lost at the slack side or bottom of the eccentric strap. If the oil cup were mounted at *C*, the oil would be carried immediately to the top of the eccentric where the weight of the strap and rod are supported, and the lubrication would be accomplished with less oil.

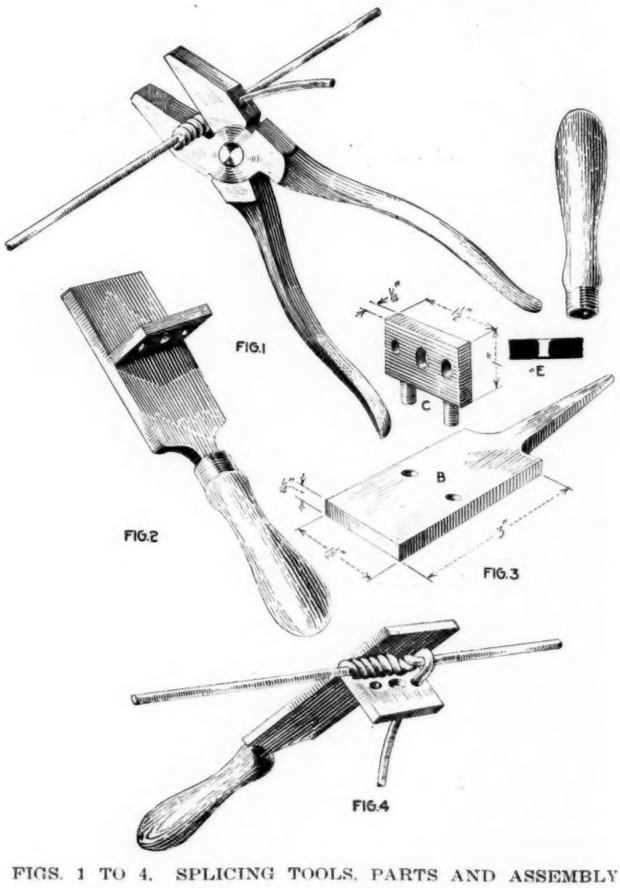
In the same plant a pair of jackshaft bearings carry a 6¼-in. shaft, the journal being about 26 in. long and constructed about as shown in Fig. 3. They are of the ring-oiling type with a single ring in the middle of the bearing, covered and hidden from view by the cap and yoke. This single split ring is not only insufficient to carry oil enough to properly lubricate the bearing, but in case of the ring stopping or coming apart, which has happened, there is no way of detecting it until the bearing is overheated. A pair of oil rings placed at *D*, *D*, with an opening over each for observation, would give better results and insure against a possible shutdown from a hot bearing.

Tools for Splicing Wire

By M. P. Bertrande

Everyone knows what a difficult job it is to splice solid hard-drawn copper or iron wire without suitable tools. In order to obtain a perfect joint, tension must be exerted on the wire ends while winding the splice, and this cannot very easily be done with the common type of cutting pliers. The self-explanatory illustration, Fig. 1, gives a clear idea of what may be done to overcome the difficulty. A $\frac{3}{16}$-in. hole is drilled in the soft part of one jaw of the pliers. Then by inserting the end of the wire to be wound and rotating the plier, a perfect tight joint is obtained.

Fig. 2 shows a wire-splicing tool that makes an excellent joint. It winds the joint tight up to the very end of the wire, something impossible with any kind of pliers. While the joint is being made, the other end of the wire is held by a pair of pliers. The tool consists of a piece of machine steel *B*, Fig. 3, to which a right-angle extension *C* is riveted. Three holes for the different sizes of wire are drilled, for holding the ends of the wire to be wound on the splice, as shown in Fig. 4. The holes for the wire should be well rounded, as shown at *E*, Fig. 3, so as to give the wire a good sliding surface.



FIGS. 1 TO 4. SPLICING TOOLS, PARTS AND ASSEMBLY

Editorials

The Pooling of Power

AT THE meeting of the American Institute of Electrical Engineers held in New York on January eleventh, there was read and discussed a very timely paper, "The Effect of War Conditions on the Cost and Quality of Electric Service," by L. S. Goodman and W. B. Jackson. Toward the close of the discussion, W. N. Smith called attention to the fact that in the large manufacturing districts in and about New York and other large cities there are, among the larger factories, many steam-power electric-generating plants which could be made available as auxiliaries to the central stations in times of emergency by commandeering them into a pooling system under the jurisdiction of Federal or state authority, which could be exercised through public-utility commissions or boards of engineers appointed for the purpose. While such auxiliary stations could not generate with as little fuel per kilowatt as the large central station, their load factors would probably be benefited. These distributed facilities and fuel supplies already existing would, in times of shortage, become immediately available for the needs of the community without having to wait longer than it would take to switch the auxiliary equipment to the existing systems of distribution.

The application to public use, on an extended scale, of such stand-by auxiliaries, would, of course, have to be carefully worked out by competent engineers, but it is perfectly feasible of accomplishment, both as to apparatus and circuit connections.

With a system of private plants pooled under control of public authority, it would become possible to enforce greater fuel economy than now exists in many of the factory plants available for commandeering, since they would be supervised by engineers who would be in a position to enforce the most economical methods of operation under the circumstances. It is an unfortunate fact that the average factory plant, in which the expense for fuel and power is small in comparison with the total manufacturing cost, is not run as economically as a similar plant owned by a public-service corporation or a manufacturer whose principal expense is for steam power. The manager of a plant of the former type pays little attention to the manner in which his steam is generated or used, provided he gets it when and where he wants it. In such cases boiler efficiency is as likely to be forty per cent. as seventy per cent. But with the system proposed, there could be brought to bear upon commandeered private plants some authoritative pressure from without, which is about the only method left to persuade an inefficient factory superintendent that it is better for him to improve his boiler and engine efficiency than to have his fuel supply for factory purposes reduced or cut off as a penalty for wasting it. Another advantage to the commandeered factory plant would be the increased certainty of its fuel supply upon becoming an auxiliary public utility.

In localities where war activities have put extra pressure upon all sorts of industry requiring fuel, it is time to apply to the central-station interests the same principles of coöperative pooling as are now being applied to the steam railroads by the highest public authority, to the great advantage of the public interest. It does not require much imagination to perceive both the ready-to-hand possibilities of helping out the central stations and of aiding in fuel conservation at factory plants used as auxiliaries, which would result from the institution of a system such as that outlined, of pooling central stations and private plants in the public interest.

The nonarrival of a single bargeload of coal, prevented by an ice blockade from reaching a central station, would not then be a matter of such moment to the community as it is now, when without warning, any part of the load on a large central station or important substation may be "pulled" by the load dispatcher and some sections of the community deprived of transportation or of the means of factory operation, or plunged into darkness.

We take occasion to remind the engineering profession and the general public of some of the methods of electric-power generation and distribution that were commonly practiced in the largest cities twenty-five or thirty years ago, in the early days of the electric-lighting industry, before the advent of the modern central station. At that period responsible central-station companies operated not only central stations of a few thousand horsepower capacity, but also had tied in with them or operating on separate circuits little isolated stations with a few small belted units in each, stuck around town in basements or in rented space adjacent to convenient boiler rooms; or else bought the output of small units operated by owners of factory plants at wholesale rates and resold the distributed output for both public and private lighting and power. To be sure, rates were higher then than now and fuel and wages were cheaper; but the point is that the public actually received pretty fair electric service from these heterogeneous, disjointed outfits operated in private isolated plants that were auxiliaries to the small central stations of that day. An emergency service from an auxiliary system of commandeered factory plants would certainly be better than no service at all from a large central station.

If this whole matter were taken up under public authority in any industrial district by the utilities commission having jurisdiction or by a board of engineers appointed for the purpose, it would be a simple matter to prepare an inventory of available isolated plants, with all necessary data as to their present duty, hours of service, usual fuel supply and storage capacity, cost of operation and the equipment and connections necessary to harness them to the existing distribution systems. With this information at hand and with the organization for utilizing it in the public interest, the central stations could be effectively supplemented and reinforced in their

important functions. The public would then have additional protection against the sudden crippling of a big steam-turbine unit or against a blockade on the fuel supply of some important central station, both of which causes have recently operated to curtail electric service in the New York district.

If the attitude of the central stations is one of helplessness in a difficult situation, for which they are not responsible, they should be willing to be helped by public authority in the interest of the public whose creatures they are and whom it is their main business to serve. No one, least of all a private manufacturing concern, wants to subtract anything from the legitimate business of a central station or any other public utility; but if the public interest in the present vital emergency requires more perfect continuity of service than the central stations can give it unaided, it would seem that a concrete, practical remedy is not nearly so remote as the pessimistic statement of the problem would lead us to believe.

By utilizing the auxiliary steam-plant resources now available, the public will be better served, the strain on man-power and on financial credit will be to a large extent relieved, the available fuel will be more intelligently used than it is at present, the private power-plant owner will be stimulated into realizing his public obligations and will be incidentally rewarded by greater certainty of his fuel supply; and while the central-station interests will not be permitted to assume that their electric-supply facilities are the only ones available in a grave public emergency, they will, on the other hand, not be expected to perform the impossible.

While it is perfectly reasonable under ordinary circumstances to consider that a central-station electric-supply system is best administered as a monopoly, the status of the central station, being primarily just as dependent on the fuel supply as the isolated plant, takes away its apparent independence, after all, and makes it really a competitor of the isolated plants, so that in its economic relation to the community it becomes subject to the principle that, as in the case of the railroads, the public interest is better served by coöperation than by competition.

The War and the Individual

IT IS highly probable that the Third Liberty Loan will be launched about March first; but this much is certain—it will not only exceed in amount the two that have preceded it, but it will be the largest single war loan ever offered by any nation.

The prompt and complete absorption of so vast a sum—and no right-thinking person has any misgivings as to the successful accomplishment of that end—will require the whole-hearted support of every loyal citizen. It will mean sacrifices greater than those that have been made; it will involve self-denial to an extent which neither necessity nor inclination have yet been able to enforce; and it will demand of the individual the giving up of purely personal pleasures and conveniences to contribute to the benefit and well-being of all. But the true American stands ready to undergo all these discomforts when he realizes that by so doing he is strengthening our fighting arm and thus bringing the end of the war nearer.

There has been an unfortunate tendency on the part of some individuals to view the war as a thing remote and detached. They agree that conservation policies are needed to prevent waste, but they have done little themselves to carry out such policies. They continue to indulge in luxuries and extravagances to which they were accustomed in peaceful times, and by that very act they divert to the production of nonessentials a part of the labor and materials which should be devoted to the one great, overwhelming purpose of the present—the winning of the war.

It is charitable to explain away such action on the ground of thoughtlessness; but to admit that excuse is to emphasize the necessity of wider publicity concerning the relation of the individual to the present conflict. We must get away from the bald statement that the nation is at war and realize that we ourselves are in the war; for, after all, the nation is but the aggregate of individuals. The responsibilities and the hardships must rest upon us in equal measure, just as we expect to share in equal measure the fruits of victory.

The scarcity of foodstuffs and the shortage of fuel have done much to impress upon the individual how close the war comes to his own doorstep. He is at last awaking to the fact that his habits of living must be readjusted to meet the greatly altered conditions, and to prevent the rapid recurrence of such stringencies as have already been experienced. The lesson has been taught severely, but the truth is wholesome.

From this time forward there will be a closer watch kept on individual expenditures, greater economy in the consumption of necessities, and a growing willingness to do for oneself the things that were formerly left to others, all of which will result in making available additional wealth and energy for carrying on the war. The Third Liberty Loan will be oversubscribed, exactly as the two that have preceded; but it will be done by the dollars of those who put necessities before nonessentials, service in place of self-gratification, and patriotic devotion above all else.

Yet it is not enough that the loan be fully subscribed; it should be absorbed quickly. The rapidity and spontaneity with which our people answer the appeal of the Government for funds will be an unmistakable indication of their interest in the war and their willingness to assume its burdens. The effect produced on the minds of German militarists by the swift raising of the whole amount of the loan is an advantage not to be regarded lightly.

The cost of running the thousands of lights which are burned unnecessarily may be insignificant, but the cost to the average householder of running a few extra bulbs overtime makes a very significant difference in the monthly account rendered. We are glad to see that Fuel Administrator Garfield has made a positive move toward restricting this waste, and hope his order will be complied with without disparaging criticism.

We have often wondered why some philanthropists and conservationists have not endowed a fund to put a few convincing talkers on the road to show power-plant owners how much their engineers may save with the aid of a water meter, coal scale, Orsat and a few thermometers. Gifford Pinchot, Andrew Carnegie and the Rockefeller Foundation please take notice.

Correspondence

Change in Water Supply for Air Pump of Leblanc Condenser

In *Power* of Nov. 20 Mr. Forseille brings up some interesting points on the subject of the change in water supply for air pump of Leblanc condenser. The two problems as stated in his query are: First, that of furnishing a Leblanc condenser with enough water to get a good vacuum; second, that of getting rid of slush ice on strainers in the water-supply line to the air pump.

The first is by far the most serious as it causes a loss during the whole year. In Table I is given a comparison of the conditions as stated by Mr. Forseille with those that would obtain with larger amounts of condensing water. Water rates of 32 (Mr. Forseille's stated rate), 45 and 60 lb. per pound of condensed steam are shown as representative of the range of possible improvement. For intermediate points curves can be drawn or reference can be had to tables of vapor tension, and this tabulation can be augmented to cover any comparisons required. In this table it is assumed that the exhaust steam discharged to the condenser contains 950 B.t.u. per pound. Under each of the three water rates are tabulated the conditions for cooling-water temperatures of 32, 60 and 100 deg. F., which nearly cover the range Mr. Forseille says he has to operate on.

TABLE I. A COMPARISON OF REPRESENTATIVE CONDENSER CONDITIONS

Lb. Water per Lb. Steam	32			45			60		
Cooling-water temperature, deg. F.	32	60	100	32	60	100	32	60	00
Rise in temperature, deg. F.	30	30	30	21	21	21	16	16	16
Discharge temperature, deg. F.	62	90	130	53	81	121	48	76	116
Vapor tension at above discharge temperature, lb.	0.56	1.41	4.52	0.40	1.06	3.52	0.33	0.90	3.05
Corresponding vacuum with 30 in. barometer	29.44	28.59	25.48	29.60	28.94	26.48	29.67	29.10	26.95

Actual vacuum is likely to be from 0.3 to 0.4 in. mercury lower than these values.

A rearrangement of the above vapor tensions and vacuums to make the comparisons more clear is shown in Table II.

TABLE II. SUMMARY OF VAPOR TENSIONS AND VACUUMS ARRIVED AT IN TABLE I.

Water per Lb.; Steam, Lb.	Cooling Water Temperatures, Deg. F. 32	60	100
32	0.56	1.41	4.52
	29.44	28.59	25.48
45	0.40	1.06	3.52
	29.60	28.94	26.48
60	0.33	0.90	3.05
	29.67	29.10	26.95

Referring to the tables, it is seen that increasing the condensing water from 32 lb. to 60 lb. will improve the vacuum about $\frac{1}{4}$ in. when cooling water is at 32 deg., about $\frac{1}{2}$ in. at 60 deg., and $1\frac{1}{2}$ in. when water is at 100 deg. The result of improvement in vacuum in terms of cash value is brought out forcibly in Mr. Baker's article in the Dec. 4 issue of *Power*.

If the pump turbine in this case is now working to the absolute limit of its capacity, little can be done but to replace it with a turbine or motor big enough for the job; but if it is capable of being speeded up by overhauling or readjustments, there can be no doubt that it would pay.

I notice that Mr. Forseille says that the air-pump supply valve is kept at a constant setting under all conditions. This suggests to me that it may be taking more water than necessary and, if so, is giving the turbine extra work to do from which there is no return.

The vapor tension values used above are from a table given by the Westinghouse Machine Co. in its instruction book WM 102.

The second problem is that of preventing ice formation on the strainers in the supply lines to the air pump. One point involved here is that of vapor tension of the hurling water. As this water is depended on to condense any condensable vapors that may reach the pump, and as it passes through a region of vacuum after it passes through the blades of the impeller, the vacuum produced is controlled by the temperature of this water and its corresponding vapor tension. See the tables.

Another factor of importance is the air discharged, entrained with the water, through the main discharge pipe. There is always some air passing out of the condenser in this way, the amount probably varying with the depth of submergence of the pumps; but if the pumps are run fast enough to lower the water level to the suction opening of the pumps, additional air will be trapped and carried out with the water. To use this water in the air pump would add to the free air in the condenser. It would also be likely to interfere with proper working of the air pump by breaking up the "water pistons" as they leave the impeller blades.

If Mr. Forseille had given more details as to elevations and the vacuum gage readings on suction or injection lines, more might be said about how operating conditions could be improved.

For preventing ice forming on the screens I suggest tapping in a jet of steam or hot water just below where the air-pump line leaves the main line or a jet just ahead of each screen.

The above discussion was written before reading Mr. Johnson's contribution in the Dec. 18 issue, and from the start it was assumed that it was impossible to follow the scheme Mr. Forseille suggests. C. W. BELL.

Hauto, Penn.

Worn Latch Blocks Cause Racing

When I took charge of this plant, which is equipped with Laidlaw-Dunn-Gordon-Hamilton gear pumping engines, I had a great deal of trouble with the latch blocks wearing and the engines racing, caused by the head end letting go too early and the crank end going in full gear or not unhooking at all. I did not know what the matter was; neither did the builders nor those who did the erecting. The crank end would go in full gear about every third or fourth revolution, so

you can imagine what a time I was having. I had been a marine engineer and had had no experience with Corliss engines, but it occurred to me that possibly the blocks were unlatching too soon; so I put my thumbs on the springs to help the tension of the springs, and to my surprise the engine stopped racing. I then got wise and turned the blocks around so that new edges or sides came together. That was all right so far, but all the service I could get out of the new edges was about 15 days, after which they would begin to cause racing again.

One day when *Power* came, I sat down to read it, and under the head of "Correspondence" I came across a letter by an engineer who had been having the same kind of trouble that I was having. He said that he had had blocks made out of No. 00 steel and it cured the trouble. I made up my mind that if it was a good thing in his case, it would be good in mine; so I had similar blocks made and put a set on one engine Aug. 3, 1911, and on another Sept. 30, 1911. I have not had a bolt out of one of them since.

If there is anything in this that you think worth publishing, do so, but do not send me anything for it, for I do not want it and will surely send it back if you do, as it is written in gratitude for the "pointer" received from *Power* several years ago. I hope this may do someone some good. R. A. DAVIDSON.

Colton, Calif.

Operating Two-Phase Motors Single-Phase

A number of years ago, when the plant in which I am employed was built, two-phase alternating-current equipment was selected, consisting of one 50-kw. and one 75-kw. generator, with exciters, supplying twenty 5-hp. induction motors of the squirrel-cage type, some fifty inclosed arc lamps for general illumination and about two hundred and fifty 16-cp. carbon lamps for local lighting. The motors were 220 volts as well as the carbon lamps. The arc lamps were of the multiple type, and groups of four were served by compensators or balance coils, furnishing 110 volts. Shortly after the plant was put in service, business became dull, and as a result many of the machines were shut down; consequently a number of the motors were running considerably under full load, causing the power factor of the plant to be low.

A test was made, and the load conditions of the plant at that time were about as follows: Apparent kilowatts as shown by the ammeters and voltmeters, 47.4; true kilowatts as shown by direct-reading wattmeters, 19.6; power factor at switchboard, equal true kilowatts ÷ apparent kilowatts = 19.6 ÷ 47.4 = 0.41.

As the 50-kw. generator, which was supplying the load at that time, was heating considerably, it was decided if possible to improve the power factor. After considering several plans, I fell upon the idea of operating the two-phase motors single-phase, starting on two-phase and then cutting one phase out when the machines were up to running speed. This would give the single-phase in use nearly full load and perhaps correct the power factor. I also discovered that by removing two contact blocks I and II, shown in the figure, from the drum of the auto-starter, one phase could be cut out when in the running position. Since with this type of compensator the drum always turns in one direction, the section with the two contacts removed would be in phase *A* at one time when starting and the next time in phase *B*. The motors were started and stopped twice per day, consequently if phase *A* was in service in the morning, phase *B* would be in use in the afternoon, so that both sets of windings of the stator would be in use during alternate halves of the day. However, if for

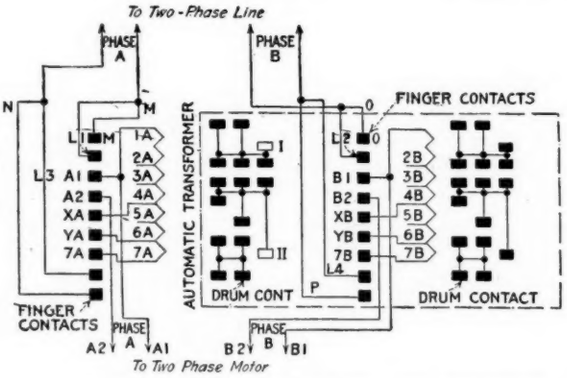


DIAGRAM OF COMPENSATOR CONNECTIONS

any reason any of the motors were stopped during the day, the handle of the starter would have to be thrown over twice to maintain the load balance in the phases. Two ammeters on the main distribution-panel box circuit indicated the load in each phase, therefore making it possible to see that the system was kept as nearly balanced as possible.

One motor was at first arranged to run single-phase as planned, and operated for a week with no trouble. The manufacturers of electrical equipment were then consulted as to what would result from the change. They replied that under the circumstances there would be a slight improvement and that no harm could come to the apparatus operating under such conditions. Eight motors were run on that plan during slack seasons, which occurred during every summer and recently both summer and winter; but I had never known, owing to the lack of proper instruments, how much improvement the change had produced until in October, 1916, when, owing to the high price of coal and the difficulty in obtaining it, the manager was persuaded by a central-station company to permit a test to be made by their expert. The result of the test was as follows: Apparent load, 37.125 kw.; true load, 19.4 kw.; power factor = true load ÷ apparent load = 19.4 ÷ 37.125 = 0.52. It will be seen that although the true load in both tests was nearly the same, the apparent load was much less with part of the motors running single-phase.

During recent years the tungsten incandescent lamps have been substituted for the arc lamps, and in order to permit the use of the 110-volt current necessary, the old balance coils of the arc lamp were employed with satisfactory results, 3000 watts or less being carried by each without difficulty and with very little heating. These coils are arranged on the roof trusses, one in the center of each group of lamps. When the incandescent lamps are burning, they have practically 100 per cent. power factor, and the power factor on the whole circuit is 76.8 per cent., the power factor of the motor load be-

ing as stated. With every machine in the factory running and all motors operating two-phase, the motor-load power factor was 66 per cent. With this motor load and the lights all on, the power factor was 77.4 per cent. These are the central-station company's own figures.

Weehawken, N. J. F. W. PLUMB.

[Operating polyphase motors single-phase is a practice that in general is advised against, but under the conditions it would seem to have some advantages. *Power* invites the opinion and experience of interested readers on the foregoing subject for publication.—Editor.]

Modification of the Pitot Tube

It would appear that the modified Pitot tube depicted on page 876 in the issue of Dec. 25, 1917, is not fully described or else is entirely erroneous. The static pressure within the pipe would cause a full-caliber flow through the valve even if there was little or no flow in the main, therefore the slight velocity head added in any case would make little difference.

It is possible that the intention is to calibrate or measure the flow through a restricted orifice under a given pressure at no flow, then measure the flow under the combined influence of the static and velocity head and calculate the velocity from the increased delivery. At any rate the contrivance does not seem to be logical as presented. J. LEWIS.

New York City.

Electric Lights for Small Plants

When on an automobile trip recently, I stopped at the pumping station of a Massachusetts town. I was cordially greeted by the engineer who, among other things, took pride in his lighting set inasmuch as it was original and, as he thought, cheap to operate. Fig. 1 shows the set, which consists of a small Pelton waterwheel direct-connected to two small direct-current

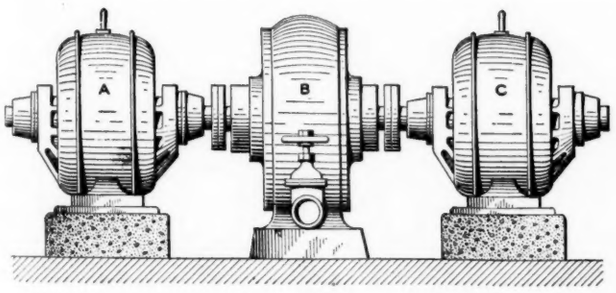


FIG. 1. TWO GENERATORS DRIVEN BY A WATERWHEEL

generators. The wheel's water supply, at 180-lb. pressure, is through a 2-in. pipe connected with the pressure pipe of pumping engine, and the discharge from the wheel is connected to the pump suction. The engineer claimed that the cost of current was considerably less than two cents per kilowatt-hour.

In another plant visited, the generator was driven as shown in Fig. 2. Two heavy iron columns *D* were erected near the flywheel of the pumping engine, and two long screws *E* were secured to them on which two bearings *C* could be raised or lowered at will to bring the leather-covered pulley *B* in contact with the flywheel.

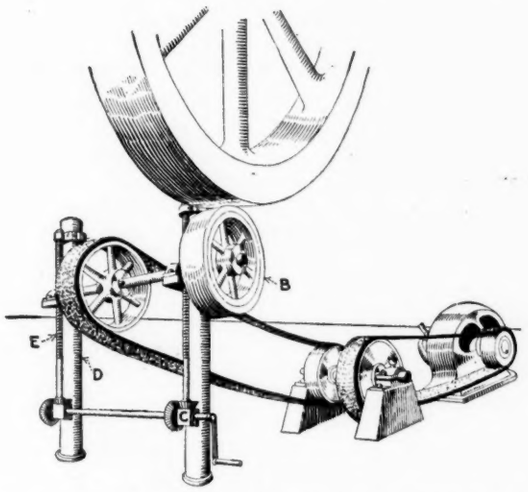


FIG. 2. DYNAMO DRIVEN FROM A FRICTION PULLEY

By this means the station was electrically lighted, otherwise oil lamps would have to be used.

Methuen, Mass. P. E. MERRIAM.

Care of Hydraulic Elevators

Hydraulic elevators require more attention than electric, and where there are a great many cars in service they should be placed under the management of a competent elevator man.

On high-pressure systems the pilot valves will most frequently require attention, as they become clogged with dirt and particles of packing carried through the pipes, and must be blown out. Next comes the packing of operating valves with leather cups, which either blow out if end cups or blow through if inside, either of which will cause the car to creep or settle. Motor valves, operating the pilots, should also be inspected and the flax packing rings renewed if necessary.

Each morning the water that has accumulated in the lunger pans should be removed and the plungers oiled (while running) with lard oil, as this is best where there is water. When the glands are within a half-inch of all the way in, the stuffing-box should be refilled with flax packing.

Hoisting cables will need to be shortened occasionally as they lengthen with wear. This will be determined by running the car to the upper floor and observing whether it comes flush with the floor or falls short. Cutout, operating (or tiller) and governor ropes should be inspected weekly, because much damage can be caused by the failure of any one of them. The practice of relying on the insurance inspections, occurring as they do about once in three months, is very bad.

Phosphor-bronze is the best material for the main operating valve, as a soft brass one will soon wear to a shoulder from the constant rubbing back and forth, and these valves should be purchased as unfinished castings so that the small holes can be drilled in as desired. The brass bushings in the pilot valves will

require to be renewed occasionally and of course must be made a driving fit.

Of the safety devices on elevators, there is one that I believe should be especially mentioned, and that is the valve lock that prevents the car from being moved if any gate in the shaft is open even a fraction of an inch. Many accidents occur at the gates, as the operator is prone to start the car first and shut the gate afterward, but with this device in operation the car remains stationary until the gate is closed. It will not, however, prevent a car from settling or creeping, as that is caused by defects before mentioned, but it does prevent the operator from starting the car before closing the gate.

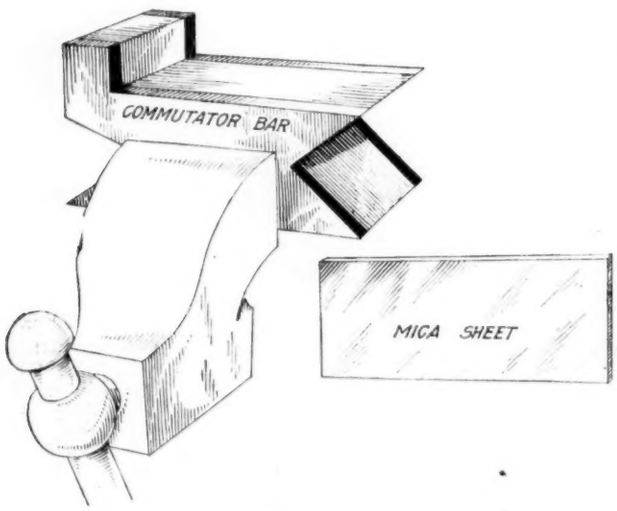
The surge tank will need a thorough cleaning out about once a year to keep the system clear of dirt, etc., that may lodge in the pilot valves and cause serious trouble.

W. T. OSBORN.

Newark, N. J.

Cutting Mica for Commutators

The following may help someone in a small shop, who has the job of cutting mica for refilling an old commutator. In a good many shops the practice is to take one of the bars, lay it on a single piece of mica, mark it off



MICA SHEETS CLAMPED FOR FINAL SHAPING

with a scriber and then cut it out with a pair of shears. A much quicker and more accurate way is to cut the mica in pieces slightly larger than the bars, then clamp about a dozen of these sheets between two of the bars in a vise and saw out to approximately the shape with a hacksaw and finish the dressing with a file.

Stone, Ky. J. E. MAY.

A Wooden Tank Repaired

A wooden water tank on the roof began to leak, and it was found that some of the planking was decayed at the tongue-and-groove joints.

It seemed that the old tank had seen its day and would have to be replaced, but one of the maintenance men suggested that it be emptied, cleaned, dried out and lined with portland cement. Lathing nails were driven all over the inside walls at about six-inch intervals, leaving each nail head projecting about one-quarter inch, after which the whole interior was plastered over, about three-eighths inch thick, and when set, the surface was washed over with a thin coating of clear cement a couple of times.

The result was gratifying, for the tank is tight, and there are no signs of further deterioration.

Concord, N. H. CHARLES H. WILLEY.

Gas Engines of Former Times

In going over our data file recently, I found a letter from a man in Pennsylvania who was using a gas engine, and I am sending you an exact copy, thinking it may be of interest, as indicating the status of gas engines at that time, the kind of service to which some were put, etc. Seventeen years have shown remarkable development in equipment of this kind.

Newark, N. J. N. A. CARLE.

..... Opera House
....., Pa., July 30, 1900.

To united Electric Company of New Jersey

Gentle Men Yours of July 27 received In regard to Gas Engines I have used automatic Gas Engine for running Dimo to Light my Opera house last winter 25 horse Power I got 300 lights I got 15 Kilowatt Dimo I had good steady light Engine run from full load to no load you now Opera house Lighting To hard on Engine we go so many dark cein we would have on 300 lights and then we would have nothin. I use natral Gas Cost me 20 cents Per thousand avrige cost Per night of run of 10 hours 27 cents Repairs on Engine for 7 months $5.67 all the Engine want is care no experimenting with It and It will work all right I consider the Engine as a hole a good one

Now for Its disinantiges It Is hard Engine to Start I have been starting mine with Powder and It Is dangerous and leavs a bad smell In house your Electric Spark must be Perfect and your Storige battry must be all right the battries I got with Engine Is now Plaid out there was 4 cells I wish you would send Me the adress of some good firm I will have to have Storige battries before I star up again I am goaning to Put In a air Pump & Tank and Start It with air this season the Engine cannot be started By hand there Is a saving to Me of about 60 Dollar Per month I consider the Engine will Pay for It self In 3 years we run the Engine 280 revelutions Per minut we get Explosing Every time If you want to now any other Point about It let me now and I will Try and Explane It as well as I can

Yours Truly, ...

Sucking from a Condenser

In reply to Mr. Baer's request, on page 807 in the issue of Dec. 11, for a sketch and description of how an engine could suck up a cylinderful of water from the condenser, I will say that I cannot furnish a sketch of the piping as I have been away from the plant for some time and cannot get a correct sketch of it. Maybe I was in error in saying the engine sucked up a cylinderful of water, for the least little bit over clearance volume is enough to wreck the engine as water is practically incompressible.

The condenser was an old-time Conover with vertical pumps working on the same shaft. The circulating water also sealed the condenser, and when the latter was shut down and the circulating water not shut off, the steam could not exhaust and was condensed, and when the engine made a return stroke the water was sucked back, or a portion of it, owing to the vacuum not being entirely gone.

W. H. NOSTAN.

Philadelphia, Penn.

Inquiries of General Interest

Dry Materials for Extinguishing Fire—What material could be used in dry powdered form for extinguishing fire? L. S. E.

Pulverized bicarbonate of soda (baking soda) or pulverized salt is a good material for extinguishing fire. Dry sand is a good material for smothering small oil fires.

Lengths of Splices for Leather Belts—What is the rule for the length of splices for leather belting? W. R. K.

For belts up to 10 in. wide, make the splices 10 in. long. Belts that are 10 to 18 in. wide should have the splices as long as the belts are wide. Eighteen inches is the greatest length required for the splice of a double belt.

Steam Cylinders for Compound Duplex Pump—A compound duplex steam pump of 12-in. stroke and having 8½-in. water cylinders is to work against a discharge pressure of 180 lb. per sq.in. What should be the sizes of the high- and low-pressure steam cylinders if exhaust takes place against 2 lb. pressure above the atmosphere? G. R. W.

With ordinary clearance and other proportions of design, each side of the pump should have a 9-in. diameter high-pressure and 15½-in. low-pressure steam cylinder.

Rating Boiler Size on Heating Surface—In rating boiler horsepower according to the number of square feet of heating surface, is not superheating surface to be included? L. G.

The horsepower rating according to heating surface is purely commercial. Water-heating surface, or surface in contact with fire or hot gases on one side and water on the other, is very effective in transmitting heat, and this is the principal kind of heating surface in nearly all types of boilers and in most boilers it is the only kind. The heat transmission through superheating surface which has fire or hot gases on one side and steam on the other side is very slow, and it is not customary to count in this kind of heating surface in rating the nominal or manufacturer's horsepower of a boiler. The superheating surface should be separately stated as such.

Air Gathered in Feed-Water Oil Filter—The returns of a vacuum steam-heating apparatus are delivered to an air-separating tank and thence discharged to a receiver and boiler-feed pump. After being discharged by the pump, the return water, on its way to the boiler, is passed through a cloth-bag filter for removal of the oil. Air collects in the upper part of the filter. What is the cause and remedy for removal of the air gathered in the filter? G. G. W.

It is probable that the "air" complained of consists of oil vapor and air liberated out of the water when the pressure of the water is suddenly reduced, after being subjected to the greater pressure necessary for forcing the water through the filter. If it is permissible to have a small air space in the top of the filter, the air or vapor can be relieved automatically by connecting a float type of radiator air valve with the upper part of the filter chamber, or with an appropriate enlargement of that space by employing a small air chamber made of pipe and fittings.

Advantages and Disadvantages of Steam Dome—What are the advantages and disadvantages of providing a horizontal return-tubular boiler with a steam dome? L. D.

The advantage of a steam dome on a boiler is that it increases the volume of the steam space and allows the steam to be taken from the boiler at a point somewhat removed from the surface of the water, thereby insuring a supply of drier steam than if the supply were taken directly from the shell. The leading disadvantages are the added expense, difficulty of making and maintaining safe and tight connections of the dome with the shell and the uncertain weakening effect of the dome opening on the shell. The advantage of obtaining drier steam can be met, however, by a good form of dry pipe or separator placed within the shell or by employment of an exterior steam drum. A steam drum with nozzle connection to the shell is usually less expensive than a dome, and besides affording the opportunity for much safer construction has all the advantages without any of the disadvantages of a dome, excepting the requirement of practically the same if not less headroom.

Independent Stacks for Horizontal Return-Tubular Boilers—For a suburban factory power plant, begun with the installation of two horizontal return-tubular boilers that probably will be duplicated within a year, would it be better to supply each boiler with a separate steel stack set over the uptake, or provide a steel stack that will be adequate for all boilers? J. B. N.

The best draft control would be obtained by furnishing each boiler with a separate stack, but placing the stacks directly over the boiler uptakes is objectionable on account of the expense of providing supports suitably independent of the boiler settings and trouble will be experienced from soot and scale dropping from the inside of the stacks into the uptakes of the boiler. The arrangement also would be likely to give trouble from rain water running down the sides of the stacks and finding its way to the boiler settings. These disadvantages can be obviated and nearly the same draft advantages of independent stacks can be secured by setting the stacks at the sides of the settings or to the rear of the firing spaces, and providing the connections from the uptakes to the separate stacks with easy bends. For most situations the independent stack supports and connections should cost no more than proper provision for independently supporting the stacks directly over the uptakes of the boilers.

Sufficiency of Chimney Draft—Trouble is experienced in burning sufficient coal and keeping up steam in two return-tubular boilers each 72 in. in diameter and containing 92 tubes 3½ in. diameter by 18 ft. and with breechings connected to a brick stack 48 in. in diameter at the smallest part and 80 ft. high. Is the chimney size at fault, or if not, what may be the cause of the trouble? W. K. C.

The rated size of each boiler is about 150 boiler horsepower. Allowing for combustion of 5 lb. of coal per boiler horsepower, ordinary form of breeching and other smoke connections, a fair quality of fuel and proper firing, the chimney should be adequate for about 310 boiler horsepower or ample for the boilers. It may be that the draft is impaired by proximity of high hills, or that air enters cracks or opening in the chimney flue or connections. The size and form of the connections from the boilers may be at fault for realizing the draft effect of the chimney. The uptake from each boiler should have an unobstructed cross-sectional area of not less than 775 sq.in. The cross-sectional area of the breeching and connections to the chimney should be not less than 1600 sq.in.; the breeching should be provided with a baffle for carrying the smoke of the boiler farther away from the chimney over or around the uptake of the boiler nearer the chimney,and the breeching connections, especially the junction with the chimney flue, should be beveled or curved to admit of easy passage of the gases.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

The Failure of Boiler Plates In Service*

By E. B. WOLFF†

The author's investigations show that peculiar cracks in boiler plate occur at the riveted joints in all boilers examined. These cracks are found on the inner surfaces of the rivet holes or on the surfaces of the plates where they are held together. The cracks are due to fatigue.

THIS research was undertaken with the view of finding the causes of the cracking of boiler plates over the riveted seams.

The boilers were of the single-ended ordinary marine type, with three flues. The shell plates and the rivets were generally approximately 32 mm. (1 in.) thick, made some from basic and some from acid openhearth soft steel with an ultimate tensile strength of 42-48 kg. per square millimeter (59,700 to 68,000 lb. per sq.in) and an elongation of 23 per cent. to 20 per cent. on 10 diameters. The phosphorus and sulphur contents had to be under 0.05 per cent. Most of the boilers with the cracked plates belonged to steamship companies, the boats of which made voyages with a great many stops, so that the fires were frequently extinguished and relighted. Most of the boilers being oil-fired, this could be done very easily. The plates of coal-fired boilers, however, cracked in the same manner. Boilers made of the same material for other companies, the boats of which had only long nonstop runs, did not fail.

Cracks at First of Microscopical Dimensions

All the cracks found are, in the beginning, defects of microscopical dimensions. After having increased in length and breadth, they could be detected. It would occur that a boiler, the side seam of which had failed, would be sent back to the boiler shop to be fitted with a new shell plate. After detaching the front plates, nothing abnormal would be seen, and it would be decided to make use of the old front plates and fit new shell plates to them. The shell plates were bent with great care to the radius of the front plates and bored in position. When the first rivet joining the front and shell plates was put in, cracks appeared in some of the old rivet holes of the front plate. By a renewed examination of the other rivet holes, after cleaning the metal by scraping it carefully and later etching it, minute cracks were detected. The etching of the front plate, in the manner presently to be described, disclosed a great many miniature cracks, so that it was impossible to use it any more.

As already stated, the cracks were found in the butt joints as well as in the lap joints, but in all cases they started either from the inside of the holes, in two places, where the highest tensile stress occurred, or at the surfaces of the plates, where they were pressed on the surfaces of other plates. The fact that cracks start frequently on the inner surfaces of boiler plates has been mentioned by several investigators,[1] but a good indication of the causes has not been given.

The cracks cover a certain part of the surface, depending on the direction of the stresses that acted on that part. Where they are found in the rivet holes of the plates, they occur generally on two sides of the holes; in the case of the pipe holes of the tubular boiler, they spread from the top of the hole inward. When they occur on the surface of the plate, it is in general mostly around the rivet holes, but also in other places.

As mentioned, the cracks start as miniature surface cracks of microscopical dimensions; it appears that every little crack has been formed by itself, without the slightest reference to its neighbors. A polished and etched section through these cracks shows that the crystallites in the immediate neighborhood have not been deformed. The structure of the material has in most of the cases been found quite normal, no free cementite being present. Afterward the cracks grow in length and depth, and unite in longer ones, forming a peculiar stepped line.

Peculiar Destruction of Surface Layers

All evidence points to a peculiar form of destruction of the surface layers of otherwise very plastic metal. As the cracks always started at the surface of the metals and in the holes over the entire thickness of the plate, phosphorus or sulphur segregations, if these had occurred, could have had no influence. No segregations of importance were, however, found in most of the cracked plates. At first it was thought that the deformation of the material in the rivet holes made by the boring of these holes might have had a great influence. As it was not possible to produce similar cracks in holes that were bored with a blunt drill, and as pieces cut out of such a hole and bent open till the deformed surface broke showed sufficient deformation before breaking, it was concluded that if the deformation had been one of the causes, it could only have been a secondary one. As hand-riveted joints cracked in exactly the same manner as joints where the rivets had been pressed in by the hydraulic riveting machine, the pressure of this machine on the plate also cannot be the cause of the cracking.

Parts of the cracked plates, where no cracks occurred, were tested by joining them by rivets, driven in with the maximum pressure the press could give. Afterward the rivets were taken out and the plates examined and bent. Here a great deformation of the surface also preceded the rupture.

To reveal the miniature cracks it was found necessary to etch the metal with dilute sulphuric acid (1 : 10) during twenty-four hours or more. Before this etching the cracks were covered by the surface oxides, and they could not even be detected after scraping the plates thoroughly. It was necessary to ascertain that this etching did not cause similar cracks. It was found that in no case of deformation could cracks be seen after etching, not even if the metal were left in the etching solution for an abnormally long time. The deformed places were corroded in most of the tests before the rest of the metal, but this corrosion never caused sharply defined cracks. By an abnormally long immersion the deformed places could not be differentiated from the neighboring metal; the cracks, however, showed very clearly. Microscopical sections through nonetched parts showed that the cracks were clearly to be seen without the aid of an etching solution.

Some parts of plates from other seams of the cracked boilers did not even show cracks after prolonged etching.

Etching an Aid in Detecting Bad Plates

The etching with sulphuric acid has been of great aid in detecting the bad plates from those that could be used again. It dissolves the metal quite regularly and discloses even the finest cracks. The only phenomenon known where cracks of the kind described have been observed in plastic material is that known as "fatigue." The beautiful researches of Ewing and Humfrey have disclosed the mechanism of the formation of these very local hair-cracks in plastic metal. A case of the formation of similar cracks in a large shaft, where overloading in service could be proved, showed quite the same kind of cracks after etching with diluted sulphuric acid.

Photomicrographs show that the crystallites in the immediate neighborhood of the crack were not deformed. This

*From report in "Engineering," London, Sept. 28, 1917, of a paper read before the Iron and Steel Institute, September, 1917.

†Bussum, Holland.

[1] C. Sulzer, "Wärmespannungen und Ritzbildungen," "Zeitschrift des Vereins deutscher Ingenieure, 1907. Report by the National Physical Laboratory of an investigation of some unusual defects in the plates of two combustion chambers on board a foreign-going passenger steamship, and note by the engineer-surveyor-in-chief: "The cracks themselves were unusual, as they appear to have started at the inner surfaces, where the plates were laid together for riveting, and were invisible until extended through the plates." —"Engineer," 1910

was also the case with the boiler-plate cracks. These parts in the boilers being subjected to stresses of such magnitude, it may be asked how it is that the few alternations during the lifetime of a boiler can cause these cracks. It may be observed, in the first place, that the ships with boilers that have cracked made relatively short voyages along the coast, and that in the beginning no care was taken to avoid changes in the steam pressure. When, later, care was taken to maintain the steam at a regular pressure, the cracking diminished, but did not stop altogether. The first boilers were oil-fired and were made of basic openhearth material; afterward boilers, both oil- and coal-fired, made of first-quality Scottish acid steel, cracked in the same manner. Notwithstanding the severe conditions of the service, the number of the alternations is, however, only few when compared with that required to produce ordinary fatigue breaks. Only when it can be proved that at the places where the cracks are found abnormally high stresses can occur, may we accept "fatigue" as the cause of these cracks. It was necessary, therefore, to start an investigation of the stresses occurring in these parts of a boiler.

It is known from the theory of Kirsch and Leon and the tests by Preuss that the tensile tension at the edges of a hole in a bar loaded in the direction of its axis may amount to three times the average tension calculated for that bar. When it can be proved that the holes of a riveted joint can behave as in ordinary bars, we have an explanation for the fact that the tension at the edges of the holes can reach a very high value. The average tensional stress in the cracked plates was approximately 11 kg. per mm. When this value is trebled we reach such a high stress in these places that very few alternations will suffice to cause a crack. It is thus necessary to prove that the friction between the plates will not be sufficient to counteract the deformation of the sides of the holes.

Using Special Type of Extensometer

With a view of testing this, and to learn the values of the local stretch in different places of the surfaces of the plates that are pressed against each other, the author has made use of a special type of extensometer, designed by Mr. Okhuizen.

It consists of two knife-edges that are pressed to the surface where it is sought to ascertain the elongation as a measure of the stress. The change in the distance between these edges, one of which belongs to the fixed part, the other to a movable one, can be read from a scale by means of a simple arrangement of levers.

The Lap Joint—It can be clearly seen that although the plates are pressed together by the rivets, the material of both plates shows a similar elongation only in the immediate neighborhood of the rivets. In all other places the elongation is different, so that the surfaces move along each other.

It can be seen that the load is more or less gradually taken over from the shell plate by the cover plates; the gradual change will be different for every vertical section through the joint, depending on the position of the neighboring rivets in relation to the section and on the pressure of these rivets on the plates.

Photomicrographs of the separation line of the two plates disclose that in those cases where the plates have been cleaned before riveting by scraping them with a stiff brush, as in normal practice, the metallic parts do not come together, but are separated by a very compact layer of some sort of oxide. This layer has irregular breadth, the surface of the plate being very irregular under this magnification. When elastic displacements of the plates occur of the magnitude demonstrated, we can easily accept the supposition that stresses will hereby be caused high enough to explain the cracking of the plates.

P. D. Merica[2] has published the results of an investigation on the embrittling action of sodium hydroxide on mild steel and its possible relation to seam failures of boiler plate. The conclusion drawn is that the influence of alkali on steel can be detected principally by means of the alternate bending test, the number of alternations being some 20 per cent. lower for the metal treated by the alkali than the values for the untreated metal. A recovery of the material occurs after a week's time of treatment at the temperature of 180 deg. C. (356 deg. F.).

I should like to observe, in the first place, that the same kind of cracks mentioned in the present paper was found by Mr. Merica in different kinds of boilers; that the cracks described by me have occurred not only in the water space, but also in the steam space of boilers; that the cracks being extremely local, in most cases no leakage was observed and no boiler scale was found between the plates; that as the boilers crack after having been in service for one or more years, recovery of the material from the effect of the alkali, mentioned by the author, should have taken place long before the cracks started.

[2] "Metallurgical and Chemical Engineering," May, 1917.

Baltimore Encourages Fuel Economy

Baltimore, despite its proximity to the coal fields, and that it is a great coal-distribution center, suffers in common with other Atlantic coast cities from shortage of coal. The water power available, chiefly from the large station at McCalls Ferry on the Susquehanna River, has prevented such extended interruptions of service as more northern localities have experienced.

Recognizing the need not only of interesting the industries in fuel economy, but of discussing specific measures to achieve it, the Baltimore Section of the American Society of Mechanical Engineers, the Engineers' Club and the City Club held the first of a number of large meetings at the City Club, Thursday evening, Jan. 10. The meeting was made possible chiefly through the efforts of Prof. A. G. Christie, of the engineering department of Johns Hopkins University. Harry D. Bush, president of the Engineers' Club, presided. Besides many plant owners and managers and professional engineers, there was the largest gathering of operating engineers and firemen that ever came together in a local meeting, it was said.

The main address was made by Charles H. Bromley, associate editor of *Power*, and that part of it directed particularly to firemen and the operating men appears on page 146 of this issue.

Mr. Bromley said that while the many efforts made to educate the fireman would doubtless do good, it was his opinion that because of the urgency of coal saving, the best way to meet the situation was the payment of bonuses to the boiler- and engine-room crews for coal saved. The most suitable method of bonus is not to be expected at first, but some form may be used in the beginning and perfection developed as the result of experience gained. The speaker regretted that it was not possible to give more than the fundamentals on which to base a bonus system, declaring that an equitable bonus for a particular plant required particular study. The fundamentals, he said, were, first, the ease with which saving could be effected; second, the magnitude of the saving; and third, the number of persons to participate in the bonus. In conversation subsequent to the meeting Mr. Bromley said he believed the rate of payment in bonus should be based either upon the weight of coal saved per unit of output or upon the price per unit weight of coal saved per unit of output.

The speaker urged manufacturers and plant owners to inquire into the equity and adequacy of the wages paid their power-plant employees, declaring that there is no small measure of unrest among engineers and firemen. It would be well, he said, to inquire if it would not be well to anticipate organized effort on their part to secure fairer remuneration. Engineers, on the whole, have not organized in a labor way, having faith in the "learn more, earn more" slogan. The employer would do well to strengthen this faith rather than weaken it.

The fuel crisis has lent great impetus, Mr. Bromley said, to the use of the lower grades of coal, and although the engineers and firemen of Baltimore scorned hard coal, it is likely that they, in common with men of other sections of the country, must learn to burn mixtures of the Somerset semibituminous, widely used in Baltimore, and culm.

It is the speaker's opinion that the advantages of operating engines and turbines on a compromise back pressure are not widely enough known or thought of by those in-

stalling power plants for mills, buildings, etc. With compromise back pressure the engine or turbine is operated condensing, the condenser being "hooked up" to the return of the heating system, while the steam supply to the heating system is taken off the main exhaust steam line between the unit and the condenser, with a valve to control the steam flow. The back pressure on the engine is varied from the most economical vacuum, say 26½ in. in summer to, say, 1 lb. gage during extremely cold weather. Mr. Bromley referred to the Mar. 27, 1917, issue of *Power*, in which he described, with drawings, an installation of this kind at the Lynn (Mass.) Realty Co.'s buildings. The extraction turbine offered similar possibilities, said the speaker.

Following Mr. Bromley, George Goodwin, engineer at the Sheppard-Pratt Institute, representing the American Association of Steam Engineers, spoke on coal saving by care in ventilating buildings. John Powell, of the International Association of Steam Engineers, encouraged the use of combustion and other appliances for saving coal. Charles L. Mintien, of the National Association of Stationary Engineers, advised the consolidation of the various engineers' organizations that better educational and conservation measures might be made possible to the engineers of Baltimore. John Milne, inspector, United States Steamboat Inspection Service, encouraged saving in the small boats that ply the shore and harbor. Robert Mugford, chief engineer, Monumental Brewing Co., pointed out how licensing and examining of engineers would promote economy in power-plant operation. Philip Kirkwood, of Sharpe & Dohne, spoke on firing methods.

Prof. A. G. Christie, of Johns Hopkins University and secretary of the Baltimore section of the American Society of Mechanical Engineers, through whose efforts, chiefly, the meeting was brought about, spoke briefly, saying that if Baltimore could save 15 per cent. of its usual consumption of coal, it would amount to over $2,000,000 per year.

Captain Webster, of the Ordnance Department, gave a few rousing remarks, in which he said that it required about four pounds of coal to get one pound of steel in the form of shells to where it would do the most damage to the Germans.

The Engineer's Public Duty

In the course of an address before the New York Chapter recently, President Edmund T. Perkins, of the American Asosciation of Engineers, said:

There are 56,000 engineers enrolled on the membership lists of the various engineering societies of the United States. This easily indicates a total of 100,000 engineers in active practice throughout the United States. The profession has existed and been recognized for centuries and shows a remarkable growth in numbers engaged therein, but unfortunately does not show an equal growth in position and standing in the community, for the engineer has been too much engaged with the complex problems that arise in his daily labors, to reflect on the part he has actually played or should play in society.

It has been said that the engineer is all head and no heart. This may be true of the composite head and heart of the engineering profession, but there is no more companionable, congenial, lovable man among his familiar associates than the engineer.

Now, while the engineer himself is to blame for his present position, a greater amount of blame can be attached to our engineering organizations and societies. For with the exception of the American Association of Engineers, there has not been one engineering organization or association which deals with the human side of the engineer. This one exception has awakened to the fact that engineers are not occupying their rightful position of usefulness. Engineers have considered politics as undignified and corrupting. It is true that there are corrupt politics, but this is so because men who should have kept them righteous have stood aside. There is no class of educated people more bound to traditions than the engineer. No one has made slower progress toward collective efficiency. We must join together, we must coöperate in working out reforms. A technical education never made a real engineer; 40 per cent. of his work has to do directly with humanity rather than with technicalities.

In the past the trouble has been too much modesty—too little public interest; too much independence—too little coöperation; too much technicality—too little humanity; too much aloofness—too little goodfellowship.

The engineer of tomorrow, if he is to assume and maintain the position in society that his past achievements entitle him to, must become a man of larger sympathies and wider visions. He must play more and work less by himself. He must aspire to hold the honorable offices of the state, that he may administer them for the public welfare. He must be an arbiter, not an advocate, and he must have for his watchwords, Service and Coöperation.

Electric Motors for Ammonia Compressor Drive

The largest meeting yet held by the New York Section of the American Society of Refrigerating Engineers occurred Tuesday evening, Jan. 15, at the Machinery Club, 50 Church St., New York City. About sixty were present. The section has forty members, all of whom are members of the American Society of Refrigerating Engineers, the parent body. At the yearly meeting of the parent society in December, changes to the constitution were proposed to allow local sections to have affiliated members who are not members of the parent society. This amendment will likely pass at the next yearly meeting, and in the meantime the New York Section will take in affiliated members, refunding their dues of $6 per year if adverse action is taken on the amendment at the parent society's meeting next December.

The question of a suitable emblem for affiliated members came up for considerable discussion, but was left open.

A committee of three will be appointed by the president to assist the A. S. R. E. Subcommittee on Refrigeration in the Council of National Defense. F. E. Matthews and Henry Torrance are the members of the parent society serving on this subcommittee.

The nominating committee, consisting of F. E. Matthews, William Ross and Karl Zesterdahl, nominated L. Howard Jenks, New York manager of the Frick Co., president of the section to succeed John E. Starr, whose term expires. Mr. Jenks has been acting president during nearly the whole year, Mr. Starr having been and still being ill. Mr. Jenks was elected. The secretaryship was left open on the expiration of the term of Van R. H. Green. Charles Herter, who has been acting secretary during most of the year, was requested to continue as such. Mr. Herter is responsible for much of the success of the section's meetings.

Without attempting to criticize, President Jenks emphasized the need of greater thoroughness in drawing up specifications for refrigerating apparatus specified by the Government for various purposes. The sixteen specifications now circulated show the need of the application of engineering attention, suggested Mr. Jenks.

W. J. Moore, of the New York office of the General Electric Co., requested that some disinterested member check over test results of and examine some small refrigerating machines about to be shipped to France for the Red Cross hospitals and food bases. The Red Cross has asked some of its members connected with the New York office of the General Electric Co. to ship these machines. The examination would, of course, have to be gratis. President Jenks appointed Fred Ophuls to give his services, which Mr. Ophuls expressed himself as most willing to do.

Suggesting papers desirable for presentation before the section, Mr. Herter reminded President Jenks that Adolph Koenig promised a paper on brine-circulating systems; that Harry B. Joyce, of the United Electric Light and Power Co., New York, promised one on electric drive for ice plants; F. L. Fairbanks, one on high-speed compressor valves. Mr. Herter said that Mr. Dickerman, of the De La Vergne Machine Co., would be pleased to present a paper on ice storage.

F. J. Bartlett, of the Electric Machinery Co., 161 Devonshire St., Boston, Mass., read a paper on the synchronous motor for ammonia compressor drive. Following are the chief points brought out by Mr. Bartlett.

Compressor design has followed closely the development of the compressor prime mover. The very slow machines of years ago were driven by long-stroke engines; the Corliss engine increased speeds somewhat, while a marked increase in speed has been brought about by direct motor drive, aided by the introduction of the high-speed plate valve of low lift for the compressor. The plate valve is good for speeds up to 240 r.p.m. About 40 per cent. is saved in floor space and headroom by use of the high-speed, motor-driven compressor. While direct drive is usually desired, Mr. Bartlett recognized that belted motors are sometimes necessary.

The speaker aimed to show that for motors of similar horsepower and speed, the full load efficiency of the synchronous motor was appreciably higher than that of the induction motor by 5 to 10 per cent., although he gave a general statement of 15 per cent. difference credited, he said, to a handbook distributed by the Condit Electrical Manufacturing Co., of South Boston. Mr. Moore said such a difference was very much too high and was not true of average standard motors of both types. Mr. Bartlett agreed with Mr. Moore.

In the past objection has been raised to the synchronous motor because of the separate excitation required. Advance in design has eliminated this objection, said Mr. Bartlett, and experience has shown that exciter troubles are not even serious enough to be a factor.

Air compressors are now without flywheel effect other than that given by the rotor of the motors driving them. This does not mean that ammonia-compressor builders should strive to eliminate the flywheel; but it is likely that they will find it advantageous to cut down the weight of flywheel used. The reason for lightness of flywheel is to reduce the starting torque.

The air gap in the induction motor is smaller than for the synchronous motor; therefore wear of the bearings may be greater without fear of mechanical and magnetic troubles.

The central station more and more demands that its distribution lines be working at high power factor. Because the synchronous motor gives unity power factor, its use is highly desirable from the central-station standpoint. Considerable emphasis was laid on this point by those discussing the paper, the substance of their remarks being given farther on in this report.

Mr. Bartlett hoped that there would be the closest cooperation between the manufacturers of motors and the builders of ammonia compressors.

Discussion

J. W. Moore, General Electric Co., New York City: Relative to the efficiencies of the two types of motors a synchronous motor of 600 r.p.m. and 200 hp. had an efficiency of 94 to 94½ per cent., and a slip-ring induction motor of the same speed and capacity would have an efficiency of 89 per cent. This represented the difference in efficiency to be expected usually.

J. C. Carpenter: It should be pointed out that the power factor would have to be considerably sacrificed to design an induction motor which would have characteristics similar to a synchronous for the same purpose.

Air-compressor builders have gone through the experience of induction and synchronous motor drive, and they have widely adopted the latter type of motor. For air-compressor drive the synchronous motor requires, to give a broad figure, about 30 per cent. with about 15 per cent. pull in. It is not certain that the ammonia compressor will take as much. Mr. Carpenter also urged the motor manufacturers and builders of ammonia compressors to come together.

Charles D. Neeson suggested that the section seek a paper dealing with results found in experimental work to be done by the motor and compressor builders some time during the year. He urged that the central station present its suggestions and claims in the same paper. The matter was left open other than that President Jenks appointed Mr. Neeson to get such a paper before the section.

J. W. Moore: Four years ago the first electrically driven ice plant in this section was installed on the plant of the Syracuse Ice Co. Much had been learned from this installation, and the chief thing it taught, Mr. Moore believed, was that the best plant is one that can use standard apparatus "taken from the shelf." The belted induction motor was the only logical motor at the time the Syracuse plant was built.

As showing the growth of the synchronous motor for air and ammonia compressor drive, he said that during 1917 motors to the number of 177, aggregating more than 65,000 hp., had been sold by his company.

It is Mr. Moore's belief that a compressor of speeds up to 500 r.p.m. is yet to come, and will come, and that when it does, the induction motor will be more suitable as the prime mover than the synchronous motor. Between 350 and 500 r.p.m. the controversy as to which motor is most suitable is chiefly one around the questions of simplicity and efficiency.

Harry Joyce (United Electric Light and Power Co., New York City): It is customary in this locality for the consumer to pay for the transformer losses. These are so very much greater with the induction motor than with the synchronous that it is of vital concern to the consumer. The time is not far distant when the central station must compel the consumer to stand the costs occasioned by low power factor.

Mr. Hill, of Ophuls, McCreery & Hill, consulting engineers, New York, pointed out that for the same service an induction would cost more than the synchronous motor. He also laid emphasis upon high power factor as desirable to central station and consumer, stating that a line loaded to 80 per cent. power factor gave 20 per cent. less return on the investment than was true for unity power factor, meaning return to the company selling power.

The section requested Charles H. Bromley, associate editor, *Power*, to give a paper on "Specific Fuel Wastes and Their Reduction," at the next meeting, Mar. 19. Mr. Bromley will give such a paper.

Ordnance Department Needs Civilian Workers

The Ordnance Department urgently needs several thousand civilian workers to serve in the United States. The Civil Service Commission is conducting an extensive campaign to obtain this needed help. Among the positions to be filled are the following:

Clerical Positions: 2000 stenographers and typewriters, men and women, $1100 to $1200 a year; 2000 typewriter operators, men and women, $1100 to $1200 a year; 2000 general clerks, men and women, $1100 a year; 500 index and catalog clerks, men and women, $1100 to $1200 a year; 200 clerks qualified in business administration, $1200 to $1500 a year; 300 schedule clerks, men and women, $1400 to $1600 a year; 300 production clerks, not more than $1500 a year; 200 clerks qualified in statistics or accounting, $1100 to $1800 a year; 100 statisticians, $1800 a year; 100 multigraph operators, men and women, $1000 to $1200 a year.

Testing Positions: 200 engineers of tests of ordnance material, $1500 to $2400 a year; 200 assistant engineers of tests of ordnance material, $1000 to $1500 a year.

Mechanical Trades Positions: 2500 machinists, $4 a day; 500 machine operators, $2.75 a day; 200 drop forgers, $5.75 a day (piecework); 300 tool makers, $4.50 a day; large numbers in practically all other trades.

Drafting Positions: 500 mechanical draftsmen, $800 to $1800 a year; 50 gage designers, $2000 to $3000 a year; 100 apprentice draftsmen, $480 a year.

Inspection Positions: 300 inspectors of small-arms ammunition, $1500 to $2400 a year; 100 inspectors of artillery ammunition (high-explosive shell loading), $1500 to $2400 a year; 100 inspectors of artillery ammunition

(forgings), $1500 to $2400 a year; 100 inspectors of artillery ammunition (ballistics), $1500 to $2400 a year; 300 inspectors of field artillery ammunition steel, $1500 to $2400 a year; 300 assistant inspectors of field artillery ammunition steel, $3.50 to $5 a day; 500 inspectors of small arms, $1500 to $2400 a year; 100 inspectors of material for small arms, $1000 to $1800 a year; 100 assistant inspectors of cannon forgings, $1500 to $2400 a year; 100 assistant inspectors of finished machine parts, $1500 to $2400 a year; 100 assistant inspectors of gunfire-control instruments, $1200 to $1500 a year; 50 assistant inspectors of steel helmets, $1000 to $1800 a year; 50 assistant inspectors of cleaning and preserving materials, $1000 to $1800 a year; 400 inspectors and assistant inspectors of powder and explosives, $1400 to $2400 a year.

Salaries named are the usual salaries at entrance. Higher or lower initial salaries may be paid in exceptional cases. Positions paying salaries higher than those named are usually filled through promotion.

Men only, unless otherwise specified.

For further information apply to the representative of the United States Civil Service Commission at the post office or custom house in any city, or to the Civil Service Commission in Washington, D. C. Except for the positions of stenographer and typewriter, typewriter operator, multigraph operator, and general clerk, applicants are not assembled for a written examination, but are rated principally upon their education, training, and experience, as shown by their applications and corroborative evidence.

Fuel Economy in Private Generating Plants

Engineering Offices
PERCIVAL ROBERT MOSES, E. E.
366 Fifth Avenue
New York, Jan. 15, 1918.

Mr. Albert H. Wiggin,
State Fuel Administrator,
61 Broadway, New York City.

Dear Sir—My attention has been called to your circular letter, addressed to owners and operators of private electric generating plants.

I do not think it is possible that my letters on this subject have misled you, because I have tried to be very clear in bringing out the fact that fuel economy can be obtained by operating the private plants to their limit during such part of the year as their exhaust steam can be used for heating.

If you will call up any one of fifty private-plant owners in your immediate vicinity, you will find that practical experience has shown them that they will use no more coal during the months of January, February and March, and in many cases also in April, for supplying their total requirements of heating and electricity than they would for supplying their requirements of heat alone. This is such a well-known fact that it is hardly disputed by unbiased engineers.

Mr. Bion J. Arnold, the great exponent of central plants, who is now a major in the United States Army, stated the other night at the American Institute of Electrical Engineers that there could be no question that the private generating plant using its exhaust steam was the most efficient method of producing electricity.

I would suggest that you call up Mr. Harris A. Dunn, of the Columbia Trust Co., whom you probably know, and ask him for his experience. In that building, the actual coal used in two successive years—one buying Edison current, and the other making the current—was less when the current was made than it was when the current was bought.

The same thing was true in a test we made in the Mutual Insurance Co.'s building in Richmond, and you will find that this is the universal experience.

I would like very much to come down and have a talk with you about this matter, and explain exactly what I did mean in my previous letters.

Yours very truly,
P. R. MOSES.

Research Fellowships

At the end of the academic year there will be 12 vacancies in the 14 research fellowships maintained by the University of Illinois. Two other such fellowships have been established under the patronage of the Illinois Gas Association. These fellowships, for each of which there is an annual stipend of $500, are open to graduates of approved American and foreign universities and technical schools. Appointments are made and must be accepted for two consecutive collegiate years, at the expiration of which period, if all requirements have been met, the degree of Master of Science will be conferred. Not more than half of the time of the research fellows is required in connection with the work of the department to which they are assigned, the remainder being available for graduate study. Nominations to these fellowships, accompanied by assignments to special departments of the Engineering Experiment Station, are made from applications received by the director of the station each year not later than the first day of February. Appointments are made in the spring and take effect the first of the following September.

As to the attitude of the War Department toward graduate students in engineering, the office of the Chief of Engineers has ruled that resident graduate students in engineering who are candidates for an advanced engineering degree may avail themselves of the privileges provided by the new regulations, under which engineering students may be enrolled in the Enlisted Reserve Corps of the Engineer Department and placed on the inactive list until they have completed their educational training.

Shipping Board Schools

Official announcement was made Jan. 19 by Henry Howard, Director of Recruiting for the United States Shipping Board, that under a recently issued regulation of the Provost Marshal General's department all students entering Shipping Board schools for deck officers or engineers will be exempted from military duty and will remain exempted so long as they pursue the calling for which the school fits them. This affects six hundred or more students now in Shipping Board schools and will apply to students enrolled in the future.

There are now thirty of these schools training deck officers for the merchant marine and eight training engineers. Only men who have had two years' seafaring experience are admitted to the schools. On graduation a student is either sent to sea for further training as a reserve officer in the merchant marine or is licensed at once for the grade in which he is eligible.

About four thousand new officers for the merchant marine have been licensed since the United States entered the war. The Shipping Board schools will continue to receive a limited number of students monthly, the course being one month in the engineering schools and six weeks in navigation schools.

Soldiers' and Sailors' Insurance

The Treasury Department is making every effort to have each member of America's fighting forces take advantage of the Government-insurance plan, which Secretary McAdoo asserts to be "the most just and humane provision ever made by any nation for its soldiers and sailors."

The purpose is rapidly being achieved, the insurance having passed the third billion mark in the total of policies written, and there are many military units in which every member has taken insurance.

The automatic insurance provided by the law is only partial and limited protection, payable only to wife, child, or widowed mother and ceases after Feb. 12, 1918. It is important, therefore, not only to the soldiers and sailors of the country, but to their families and dependents, that before that date they avail themselves of the full Government protection, which can go as high as $10,000 and is payable to a wife, husband, child, grandchild, parent, brother or sister.

Materials Division, Quartermasters' Corps

The following is the report of the Quartermaster's Corps, U. S. Army, Materials Division, 15th and M Sts., Washington, D. C.:

Major J. N. Willcutt in charge. Purchasing: Capt. O. F. Noss, assistants N. A. Lufburrow, J. C. McCubbin, C. G. Graves and R. T. Vaughn, buying plumbing, tank heaters and hot-water tanks; J. H. Prentiss, buying refrigerating machinery; M. O. Pinkham, buying hydrants, storage tanks, valves, wood pipe, steel pipe, cast-iron pipe and pipe fittings; E. W. Case, assistants A. F. Knibiehly and L. W. McCrea, buying ash hoists and conveying machinery; Lieut. A. C. Nell, assistant H. H. Easterly, buying pumping equipment, air compressors, rail and track materials, locomotive cranes, sprinkler systems, water meters, recording apparatus, coal and engines; Capt. W. H. Riblet, assistants S. W. Newcomb and H. Goodkind, buying heating equipment, heating boilers, heating pipe, heating tanks, feed-water heaters, boiler-feed pumps, insulating material, valves, fittings, traps, regulators and radiation; J. E. Erickson, assistants M. S. Donally and M. A. Closs, buying motors, power transformers, oil switches, switchboards, lightning arresters, series regulators, wire, electric supplies, battery-charging equipment and storage-battery trucks.

Considerable speculation has been occasioned by an advertisement which appeared on the front page of the New York *Tribune* daily for a couple of weeks, which read, "Employ Your Local Consulting Engineer," but was signed by John A. Stevens, of Lowell, Mass. It seems that the wide-awake chairman of the Boiler Code Committee got to thinking of all the coal that could be saved if everybody would follow the advice of a competent mechanical engineer, and so he ran the advertisement, hoping that it might lead to an improvement in the fuel condition by the employment, by those who might see it, of the nearest or most available consulting engineer.

New Publications

"VULCAN"

The December, 1917, issue of "Vulcan," which is the house organ of the Vulcan Steel Products Co., 120 Broadway, New York, appears in an attractive and seasonable cover. The history of steel making, another installment of which is given in this issue, is doubly interesting because of the reproduction of woodcuts illustrating early steel-working machinery. Articles on export business and a profusion of halftones round out an excellent number of this well-edited journal. Copies may be obtained free on application to the publishers.

THE OXIDATION OF COAL

Bureau of Mines Technical Paper 98, by S. H. Katz and H. C. Porter, under the title of "Effect of Low-Temperature Oxidation on the Hydrogen in Coal and the Change in Weight of Coal on Drying," gives the following as the results of the investigation:

The temperature basis of nearly all the recorded work of previous investigators of the oxidation of coal as related to the hydrogen of the coal substance was at the temperature of boiling water and above, and water was invariably produced in readily determined quantities, but three different investigators have studied the subject with regard to changes at ordinary temperatures. The results obtained by these investigators vary widely—from the statement that "quite a large amount of water is produced in oxidation" to those of the authors who can find no water produced by their method of experiment. The third investigator found that in some cases very small amounts of water were produced and in others none whatever. The authors of this paper conclude that at ordinary temperatures coal undergoing oxidation produces no water. They have also determined that the change in weight of the coal is less than that of the water removed from the coal when drying takes place in an inert atmosphere. Others have noted this discrepancy. A possible explanation is that the discrepancy results from the absorption of gas by the coal on drying.

The conclusions are: (1) There is a lack of agreement between the weight of water evolved by coal and the loss of weight when dried in an inert atmosphere; the excess weight of the coal may be due to absorption of gas. (2) A study of the vapor tension of water in coal, as indicated by the water removed by a regulated current of dry nitrogen and air used alternately, shows no production of water by the oxidation of coal at ordinary temperatures.

Obituary

C. H. Newhall, chief engineer and building superintendent of the Chamber of Commerce of Minneapolis, died Jan. 7, 1918, of pneumonia. Mr. Newhall was well known among the engineers of Minneapolis. He came from Chicago in 1909 to take the position he held until his death.

Personal

Prof. A. N. Talbot, of the University of Illinois, has been elected president of the American Society of Civil Engineers.

Guy E. Tripp, who was chairman of the board of directors of the Westinghouse Electric and Manufacturing Co., has been placed in charge of the Production Division of the Ordnance Department.

John D. Stout has been appointed Chicago representative for The Terry Steam Turbine Co. Mr. Stout was at one time assistant engineer of the company and was recently transferred from the New York office, where he was assistant manager.

Milton Rupert was recently elected vice president and assistant treasurer of the R. D. Nuttall Co., of Pittsburgh, Penn. He has been with the Nuttall Co. since March, 1893, holding various positions. In 1903 he was appointed head of the general offices. During the latter part of this period he was assistant to the president and general manager. In his new position Mr. Rupert will have charge of sales and manufacturing activities.

Engineering Affairs

American Institute of Steam Boiler Inspectors will hold its regular meeting Thursday evening, Jan. 31, in Engineering Societies Building, 29 West 39th St., New York City. The annual election of officers will take place and business in connection with the annual dinner will be taken up.

New Chapter of the A. A. E. Started in Philadelphia—The first meeting of the American Association of Engineers was held at the Bellevue-Stratford Hotel on Friday, Jan. 18. Frank P. Roth was elected chairman and a temporary club was formed with fifteen new members. A. H. Krom, general secretary of the organization, was principal speaker and he outlined the "National Association Plans." Discussion followed by T. J. Stone Edelen, Kern Dodge, Joseph B. Smith and Howard K. Hayes. The spirit of the meeting indiciated that Philadelphia will soon have a local office of the national business organization for engineers. The meeting was a close "second" to the one in New York City on the evening of Jan. 16.

Miscellaneous News

Boiler Explosion Wrecks Train — The night express train of the Rutland R.R., bound from Montreal to Boston, was wrecked near Middlebury, Vt., early Jan. 22, by an explosion in the locomotive. The fireman was killed and the engineer probably fatally hurt. Some of the cars of the train were derailed and several passengers received minor injuries.

A Boiler Explosion occurred at the sawmill of D. K. Walters at St. George, S. C., on the afternoon of Jan. 7, severely injuring three persons, including the owner and his son, the latter's condition being serious, and completely destroying the mill and machinery. Several negro workers were shaken up and mules and horses which were nearby were injured. The cause of the explosion is unknown.

A Boiler Explosion wrecked the plant of the municipal water-works at Swansea, Ill., on the night of Jan. 12, killing two men and seriously injuring two more. The plant, a story and a half brick building, was completely destroyed by fire, the village having no fire department. The cause of the explosion is unknown, but it is supposd it was because of low water in the boiler. The loss is estimated at $15,000.

A Boiler Head Blew Off in the heating system in the basement of the Chittenden Hotel, Columbus, Ohio, on Jan. 8, flooding the engine room with boiling water and steam, and injuring six men, one severely, who died later at the hospital. At the time of the explosion the men were busy removing coal from a pit near the end of the boiler to the fuel room, and when clouds of steam made it impossible for them to find their way out, they were forced to stand in the scalding water until firemen and police arrived to remove them in ambulances. The hotel manager stated that the system had been inspected and approved more than a month ago. A weak tube in the boiler was probably the cause of the accident, it was said.

Business Items

Orleans Cotton Mills, Inc., is the new name of the corporation formerly known as the Kohlman Cotton Mill and Manufacturing Co., New Orleans, La.

The Hydraulic Press Manufacturing Co. now occupies its new buildings at Mount Gilead, Ohio, and the plant is again in operation to its full capacity. The new equipment is specially adapted for the building of hydraulic presses, pumps and valves.

Ford, Bacon & Davis, Engineers, announce the formation of the Ford, Bacon & Davis Corporation, organized for the purpose of conducting a general contracting business, with particular reference to industrial, public-utility and power plants, steam and street railroads, docks, steamship and railway-terminal facilities, subways, tunnels, hydro-electric and irrigation projects. In effect this means the continuance in corporate form of construction work which heretofore has been handled by the firm direct. The corporation's organization comprises men skilled and experienced in engineering and contracting work by the most modern and economical methods. It is provided with ample capital to insure the successful completion of any work which it may undertake, and starts business with important work already entrusted to it. Its headquarters are at 115 Broadway, New York, with offices at New Orleans and San Francisco. The facilities available to the new corporation from the firm of Ford, Bacon & Davis, now in its 24th year, which continues as heretofore, assure a continuance of this firm's standard of both engineering and construction efficiency and enable both design and construction to be carried on with a degree of coördination which should make for economy and rapidity of work.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Jan. 24, 1918	One Year Ago	Jan. 24, 1918	One Year Ago
Buckwheat ..	$4.60	$2.05—3.20	$7.10—7.35	$3.25—3.50
Rice	4.10	2.50—2.65	6.65—6.90	2.70—2.95
Boiler	3.90	.....	.....	.....
Barley	3.60	2.20—2.35	6.15—6.40	2.35—2.60

BITUMINOUS

Bituminous not on market.

	F.o.b. Mines*		Alongside Boston†	
	Jan. 24, 1918	One Year Ago	Jan. 24, 1918	One Year Ago
Clearfields....	.....	$3.00	.....	$4.25—5.00
Cambrias and Somersets..	.....	3.10—3.85	.....	4.60—5.40

Pocahontas and New River, f.o.b. Hampton Roads, is $4, as compared with $2.85—2.90 a year ago.

*All-rail rate to Boston is $2.60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Jan. 24, 1918	One Year Ago	Jan. 24, 1918	One Year Ago
Pea	$5.05	$4.00	$5.80	$7.00—7.25
Buckwheat ..	4.30—5.00	2.75	5.50—6.00	6.50—7.00
Rice	3.75—3.95	2.20	4.50—5.00	4.50—5.00
Barley	3.25—3.50	1.95	4.00—4.25	3.25—3.50
Boiler	3.50—3.75	2.20	.....	.....

Bituminous smithing coal, $4.50—5.25 f.o.b.
Quotations at the upper ports are about 5c. higher.

BITUMINOUS

	F.o.b. N. Y. Harbor	Mine
Pennsylvania	$3.65	$2.00
Maryland	3.65	2.00
West Virginia (short rate)	3.65	2.00

Based on Government price of $2 per ton at mine.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide		Independent
	Jan. 24, 1918	One Year Ago	Jan. 24, 1918		One Year Ago
Buckwheat ...	$3.15—3.75	$2.00	$3.75	$2.90	$4.15
Rice	2.65—3.65	1.25	3.65	2.15	3.35
Boiler	2.45—2.85	1.10	3.55	2.00	.....
Barley	2.15—2.40	1.00	2.40	1.90	2.35
Pea	3.75	2.80	4.65	3.70	.....
Culm	....	....	....	....	1.25

Chicago—Steam coal prices f.o.b. mines:

Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.65—2.80	$3.10—3.25
Mine-run	2.40—2.55	2.85—3.00
Screenings	2.15—2.30	2.60—2.75

Smokeless Coals	So. Illinois, Pocahontas, Pennsylvania and West Virginia	Hocking, East Kentucky and West Virginia Splint
Prepared sizes	$2.60—2.80	$3.05—3.25
Mine-run	2.40—2.60	2.40—2.60
Screenings	2.10—2.30	2.10—2.30

St. Louis—Prices pet net ton f.o.b. mines a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Jan. 24, 1918	One Year Ago	Jan. 24, 1918	One Year Ago	Jan. 24, 1918	One Year Ago
6-in. lump..	$2.65-2.80	$3.25-3.50	$2.65-2.80	$3.25-3.50	$2.65-2.80	$2.35-2.75
2-in. lump..	2.65-2.80	.....	2.65-2.80	.....	2.65-2.80	.....
Steam egg ...	2.65-2.80	.....	2.65-2.80	.....	2.65-2.80	.....
Mine-run ...	2.40-2.55	3.00-3.25	2.40-2.55	3.00	2.40-2.55	2.00-2.25
No. 1 nut	2.65-2.80	3.25-3.50	2.65-2.80	3.25-3.50	2.65-2.80	2.35-2.75
2-in. screen .	2.15-2.30	3.00-3.25	2.15-2.30	2.75-3.00	2.15-2.30	2.50
No. 5 washed	2.15-2.30	3.00	2.15-2.30	2.75-3.00	2.15-2.30	2.50

Williamson-Franklin rate St. Louis, 87½c.; other rates, 72½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Lump and Nut	Slack and Screenings
Big Seam	$1.90	$2.15	$1.65
Pratt, Jagger, Corona....	2.15	2.40	1.90
Black Creek, Cahaba ...	2.40	2.65	2.15

Government figures.

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Ala., Geneva—The Geneva Power Manufacturing Co. has plans under consideration for the erection of a hydro-electric plant on Double Bridge Creek.

Ind., Ft. Wayne—The Board of Public Works plans to build extensions to the electric-lighting plant. Estimated cost, $25,000. F. M. Randall, City Engr.

Iowa, Independence—The State of Iowa plans to build a power house in connection with the State Hospital for Insane, including the installation of 1 generator and 2 boilers. H. T. Liebbe, State House, Des Moines, Arch.

Kan., Oakley—City plans to install new generating equipment in its electric lighting plant, including a 150 to 175-hp. engine and a new well and motor. G. Maurer & Son, Engr.

Ky., Jackson—The Jackson Light and Ice Co. plans to rebuild its power plant, which was destroyed by fire.

Minn., St. Cloud—The Pan Motor Co., care of G. Booth, is having plans prepared for a power house and a drop forge plant.

N. J., Kearny—The Federal Shipbuilding Co. plans to build a large power house to cost $60,000 and a boiler shop to cost $70,000 in connection with its new plant.

N. J., Toms River—The Toms River Electric Co. has been granted permission by the Board of Public Utility Commissioners to issue $15,000 bonds; the proceeds will be used for addition and improvements to its plant.

N. Y., Brooklyn—The Bureau of Supplies and Accounts, Navy Dept., Wash., will soon receive bids for furnishing at Navy Yard, Brooklyn, under Schedule No. 1664, 15,000 ft. single, stranded, rubber covered wire and interior communication plain cable.

N. C., Esmeralda—J. T. Patrick and associates plan to build a new hydro-electric plant here.

Ohio, Akron—The Goodyear Tire and Rubber Co., East Market St., plans to build a brick addition to its boiler house. Estimated cost, $100,000.

Okla., Aline—City is considering the installation of an electric-lighting plant. Burns & McDonnel, Inter-State Bldg., Kansas City, Mo., Engr.

Okla., Wewoka—City plans to install an electric-lighting plant.

Okla., Woodward—City voted to issue $20,000 bonds for the erection of an electric-lighting plant. Noted Dec. 25.

Penn., Clifton Heights—The Kent Manufacturing Co. is having plans prepared by F. E. Hahn, Engr., 1112 Chestnut St., Philadelphia, for the erection of 1-story, 40 x 67-ft. power plant. Estimated cost, $50,000.

Penn., Norristown—The Counties Gas and Electric Co. plans to issue $300,000 bonds; the proceeds will be used for extensions and improvements to its system. H. H. Ganser, Gen. Mgr.

Penn., Williamsport—The Lycoming Edison Co. plans extensive improvements and additions to its plant during the coming year. About $250,000 will be appropriated for this work.

Tex., Burnet—The Southwestern Graphite Mining Co. plans to rebuild its power house which was destroyed by fire. Loss, $6000.

S. C., Lockhart—The Lockhart Power Co., a subsidiary of the Monarch Mills, Union, plans to build a hydro-electric power plant here. E. Nicholson, Union, Treas. of the mills.

S. D., Faith—City has plans under consideration for the installation of an electric-lighting plant.

Va., Dungannon—C. F. Hagan, Bristol, trustee of P. Hagan Estate, has plans under consideration for the erection of a hydro-electric power plant on the Clinch River near here.

Va., Glenlyn—The Appalachian Power Co., Bluefield, W. Va., is having plans prepared by Viele, Blackwell and Buck, Engrs., 49 Wall St., New York City, for the erection of a steam driven electric generating plant on New River, including the installation of new equipment. Estimated cost, $2,000,000. H. Markle, Bluefield, W. Va., Gen. Mgr.

Va., Petersburg—The Virginia Railway and Power Co. plans to build an electric transmission line from here to Suffolk. C. B. Buchanan, Gen. Mgr.

Wash., Puget Sound—(Bremerton P. O.)—The Bureau of Supplies and Accounts, Navy Dept., Wash., will soon receive bids for furnishing at Navy Yard, Puget Sound, under Schedule No. 1658, air pressure reducing valves, 56 gate valves, brass, high pressure, steam and water valves, and brass low pressure, steam and water valves; under Schedule No. 1663, 16,000 ft. single-conductor, lighting and power wire and 13,000 ft. 2 conductor, lighting and power wire.

W. Va., Hartland—The French Coal Co. is in the market for an electric hauling locomotive.